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USE OF WILLOW AND ADJACENT HABITATS ALONG THE LOW FLOW CONVEYANCE CHANNEL BY WILLOW FLYCATCHERS AND OTHER MIGRATORY LANDBIRDS

1998 Final Report

to the Bureau of Reclamation and

Progress Report to the Bosque del Apache National Wildlife Refuge

from the Rocky Mountain Research Station

Prepared by Deborah Finch, Michael Means, Linda Delay, Jeff Kelly

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Date: June 8, 1999

Art Coykendall
Bureau of Reclamation
Albuquerque Area Office
505 Marquette NW, Suite 1313
Albuquerque, NM 87102-2102

Dear Art :

Enclosed is our final report for our 3-year study of Willow flycatcher migration aiong the Low Flow Conveyance Channel. If you have any requests for revisions, please let me know within 3 weeks of receving this.

Sincerely,

Deborah M. Finch

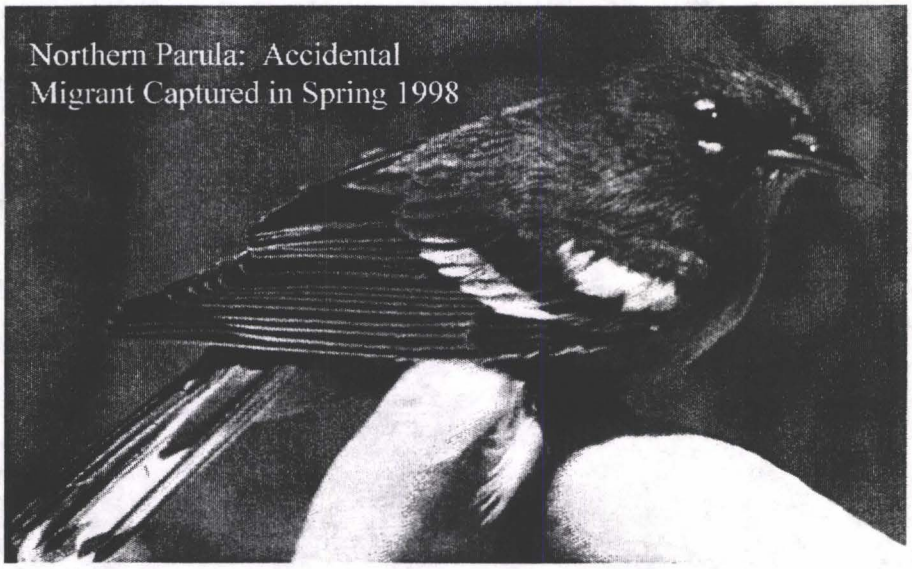
DEBORAH M. FINCH
Project Leader

EXECUTIVE SUMMARY FOR 1998 BIRD MIGRATION STUDY REPORT

In 1994 Rocky Mountain Research Station initiated a study of bird migration and their use of stopover habitat in cooperation with Bosque del Apache National Wildlife Refuge. In 1996, a new portion was added to the original study dealing with migratory bird use of the Low Flow Conveyance Channel (LFCC); this portion was commissioned by the Bureau of Reclamation. Therefore, the original study has been conducted for 5 years, spring and fall migration periods. And the new portion has been conducted for 3 years, spring and fall migration periods. The new portion was particularly focused on the Willow Flycatcher.

The original migration study focused on mixed Fremont cottonwood forest, coyote willow strips and agricultural edge habitats. A coyote willow strip along the LFCC and a salt cedar patch were added in 1996. Mistnetting was conducted in all habitats and vegetation measurements were taken to assess habitat quality. Point count transects were sampled in all habitats. These counts were done to record species not captured in mistnets and to make foraging behavior observations. In 1996, an intensive arthropod sampling regrime was added to all habitats.

This report provides a summary of data that have been gathered and interpreted over the last five years. We have described the species composition and timing of migration through the Middle Rio Grande Riparian Forests. We also describe use of stopover habitat during migration. For example, the overwhelming majority of willow flycatchers used coyote willow habitats during migration stopovers. We use foraging observations and individual bird measurements to assess change in energetic condition during stopover. We compare these observations and measurements to the structure and composition of the vegetation in the different habitats. We have a very good description of the arthropod community and how it varies between season, year and habitats. We compare the habitat use of insectivorious birds, i.e. the willow flycatcher to the arthropod community as they vary over time and habitat. We have interpreted some spatial distribution factors from our microsite and other macrosites in the Middle Rio Grande. We have provided management recommendations based on these results. We suggest that native cottonwood and willow are important habitat types for migrating southwestern willow flycatchers and numerous other migrants.



Northern Parula: Accidental Migrant Captured in Spring 1998

We intend to continue the original study this fall 1999. Because of the complexity of this information we expect to continue to interpret and report on these relationships in the future. We would like to thank all the people who have worked on this study and our co-operators; Bosque del Apache NWR and the Bureau of Reclamation.

Introduction

To investigate the use of the Low Flow Conveyance Channel (LFCC) by Willow Flycatchers (*Empidonax trailii*) and other migrant songbirds, The Bureau of Reclamation (BOR) initiated a study in cooperation with the USDA-FS's Rocky Mountain Research Station in 1996. The objective of this study was to determine the effects of a rotational mowing system on the use of LFCC by migrant Willow Flycatchers and other songbirds.

In the Southwestern U.S. riparian corridors attract a concentration of migrating songbirds; including Willow Flycatchers. The Rio Grande is the second largest riparian system in the Southwest and maintains the largest cottonwood forest in North America (Whitney 1994). This river system is also a primary source of agricultural and municipal water in both New Mexico and Texas. Cottonwood-willow habitats along the Rio Grande were historically associated with a braided river channel that meandered across a broad flood plain. The need to deliver water in a reliable manner and to limit damage due to flooding have resulted in management to reduce the meandering of the channel and the variability in river flow. Hence, riparian vegetation is restricted to the permanent watercourses that include the Rio Grande and associated water conveyance channels. One of these conveyance structures is the Low Flow Conveyance Channel (LFCC). In the 1950's the LFCC was built to carry water from the Rio Grande at San Acacia to Elephant Butte Reservoir. This diversion was necessary because too little water was reaching Elephant Butte Reservoir and saltcedar had invaded the river channel and blocked flow in several sites. The LFCC was designed to carry 2,000 cubic feet per second (cfs) from the river to the reservoir with maximum hydraulic efficiency. Water has not been diverted into the LFCC since 1985 and currently the LFCC is used to capture irrigation return flows and as a shallow groundwater drain.

The Willow Flycatcher breeds throughout the U.S. and southern Canada and is fairly abundant in the northern portion of its range. The species winters in the Choco Lowland, Gulf-Caribbean Slope, and the Pacific Arid Slope zoogeographic regions of Latin America and South America (Stotz et al. 1996); although the limits of its winter distribution are poorly known. Regional variation among breeding individuals has long been considered prominent enough to warrant subspecies designations (Phillips 1948). Currently, most experts recognize 4 or 5 subspecies of the Willow Flycatcher (Unitt 1987, Browning 1993). Recent degradation of riparian habitats in the southwestern U.S. is believed to be linked to the decline of the Southwestern subspecies of the Willow Flycatcher (*Empidonax trailli extimus*) . This subspecies was listed as endangered in 1995 and critical habitat was designated for this species in 1997. None of the habitat associated with the Rio Grande was included in this critical habitat designation. Nonetheless this area is known to be used by migrant Willow Flycatchers.

In response to these designations state and federal agencies have initiated or expanded active monitoring programs for the Southwestern subspecies in Arizona, California, and New Mexico. While the majority of these programs are focused on the size of breeding populations, reproductive success, and breeding habitat it is widely recognized that the

The vegetation along the LFCC's is comprised of primarily coyote willow (*Salix exigua*) and seep willow (*Baccharis sp.*). This vegetation was mowed annually from 1959 through 1995. As part of an agreement with the U.S. Fish an Wildlife Service the mowing of the LFCC was placed on a rotational schedule in 1996. Under this schedule 21 to 30% of the LFCC will be mowed annually. This schedule will result in multiple age classes of willow vegetation that are potential habitat for migrant birds. For instance, in our study area vegetation has grown rapidly and resulted in dense stands of 6-15 ft tall vegetation that was 8-25 ft wide. While these willow stands have not been historically available to migrating birds like Willow Flycatchers they may represent an important resource for this endangered subspecies.

In spring 1994, The Rocky Mountain Research Station initiated a study to investigate use of the Middle Rio Grande riparian habitats as migration corridors by Neotropical and short-distance migrants. Using mist-netting and survey methods at the Bosque del Apache, we have been monitoring timing, habitat use, and stopover ecology of landbird migrants. In fall 1995 we were contacted by the BOR to extend our existing study to include the LFCC. A cooperative study was established between the BOR and the Rocky Mountain Research Station in the Spring 1996. The objectives of the cooperative research are to: quantify timing, stopover length, subspecies use, and habitats of the Willow Flycatcher; verify whether willow stands have greater value to Flycatchers during migration than other habitats based on proportion of captures, weight, fat loads, and weight gain of recaptures; determine whether the presence and structural alteration of willows have potential to influence migration capture rates (an index to population size and habitat use); quantify species composition and relative abundance of arthropod food sources found in willow and other habitats, evaluate whether active management and manipulation of willow habitats along drainages can potentially improve migration habitat for Willow Flycatchers; and identify other Neotropical migratory and resident birds that benefit from the availability of drainage willow habitat. Here we report final results from the 1996, 1997 and 1998 seasons.

STUDY AREA AND METHODS

Study Site and Mist Net Operation. In 1996, 1997, and 1998 field data were collected in the first week of April through the first week of June and from the first week of August through the first week of November. In 1996, 1997, and 1998 nets were operated in willow, agricultural edge, cottonwood bosque and along the LFCC (Fig.1). Standard nylon mist nests (12 m x 2.6 m) were used. Mist nets were operated 5 days a week. Unless rain, high winds, or temperature dictated a change, mist nets were opened 15 minutes before sunrise and operated approximately six hours each banding mourning. Each captured individual was weighed to the nearest 0.1 g using a digital electronic balance. We estimated fat stores of each bird by observing the subcutaneous fat deposits in the interclavicular fossa and abdomen according to a six-point scale developed by Helms and Drury (1960). Unflattened wing chord, tarsus, tail length relative flight feather length (for wing formula calculation), presence of notch and emargination of primaries, bill width, bill length, lower mandible color, wingspan, and tail shape were measured

according to Svensson (1984) and Pyle (1997). The amount of skull ossification was examined in fall to identify age. Plumage color and relative contrasts between body parts were recorded by referring to the color standard of Smithe (1975). Each bird was banded with a numbered aluminum leg band.

The same 14 net sites along the LFCC were used in 1996, 1997, and 1998. These net sites were located on the west bank of the LFCC, immediately south of the North Bosque del Apache National Wildlife Refuge Check Structure. We selected this location for the following reasons: 1) the willow growth in this section was typical of the LFCC, i.e., data collected from the area would be relatively representative of the entire LFCC; 2) the area was close to our original study site, therefore, this data set could be used as a spatial control for comparisons and it also made it possible to operate both net site concurrently. 3) the site was inside the Refuge boundary and, therefore, the probability of nets being vandalized was reduced. To maximize capture rate, nets were set up approximately perpendicular to the LFCC at 30-50m intervals.

In addition, the 5 nets sites established in salt cedar habitat adjacent to the LFCC in 1996 were also operated in 1997 and in 1998 an additional 2 nets were operated in this habitat bringing the total to 7. Of the 14 nets operated in the cottonwood habitat in 1996, 7 were operated in 1997 and 5 were operated in 1998. The number of nets in the willow habitat was increase from 3 in 1996 to 4 in 1997 and decreased to 2 in 1998. Netting effort remained constant at 3 nets in the agricultural edge habitat. In total 39 nets were operated during 1996, 35 nets were operated in 1997, and 31 were operated in 1998. Because some of our net sites changed among 1996, 1997, and 1998; we needed to standardize our capture data to make comparisons. For this purpose we calculated our banding effort in each season in terms of net-hours. A single mist net operated for one hour is a net-hour.

Willow Flycatcher Identification. Willow Flycatchers are difficult to distinguish from Alder Flycatchers (*Empidonax alnorum*) in the field (Stein 1963, Pyle 1997). Most individuals (90%) of these species can however be separated based on Stein's formula, which combines several wing measurements and bill length (Stein 1963). Alder Flycatchers have not previously been recorded in New Mexico (Williams 1997), but to demonstrate that the birds that we captured were Willow Flycatchers rather than Alder Flycatchers we undertook this analysis. We also identified Willow Flycatchers to subspecies in the field. These identifications were based on a number of morphological and coloration measurements. Because there is no proven method of validating these subspecies identifications, they should be applied with caution (Yong and Finch 1997). It is unlikely that every individual was classified correctly and the total accuracy cannot be estimated. Here we report some analyses designed to uncover potential distinctions among subspecies. We distinguished four Subspecies (Browning 1993): *Empidonax trailii adastus*, *E.t. brewsteri*, *E. t. trailii*, and the Southwestern form *E. t. extimus*. For most of this report we distinguish only those birds categorized as endangered southwestern Willow Flycatchers and lump those of other subspecies.

Arthropod Sampling. We compared arthropod diversity and quantity of insect prey trapped in LFCC willow with that of nearby vegetation types in an attempt to examine the importance of willow to migrant birds. We quantified arthropods available to land birds by sampling with pitfall and glueboard traps in 1996 and adding sweep-net samples to these methods in 1997 and 1998. Several sampling methods were used because each method is biased towards particular taxon (Cooper and Whitmore 1990). Our choice and location of arthropod sampling was driven by the objective of relating avian abundance to potential arthropod prey. Samples were randomly placed within the vegetation < 10 m from a subset of the mist nets in each vegetation type. Each trap was marked and relocated each year for repeated sampling. Sticky, sweep net and pitfall trap samples were collected weekly. The pitfall and glueboard traps were set between 10:00 am and 12:00 pm and were collected at the same time on the following day. Sweeps were conducted throughout a similar two hour period. The time that pitfall traps were left open was increased to 3 days in 1997 and 1998 in an effort to sample more diversity. We also recorded all arthropods trapped in the mist nets in 1997 and 1998.

Glueboard traps were yellow cardboard, approximately 13 cm x 18 cm, and coated with Tanglefoot™. Clothespins were used to attach the glueboards to vegetation 1.5 meters from the ground. These traps were collected and stored in Ziplock™ freezer bags.
This trapping method is biased toward small flying insects and mobile foliage arthropods.

Pitfalls were used to trap ground traveling arthropods. Our traps were 16 oz. sized containers, buried to ground level. In response to erosion, soil and litter were periodically replaced around the rim. We used approximately 50 ml of a relatively nontoxic antifreeze, Sierra™, as a kill agent and preservative. Arthropods were stored in jars of 70% ethanol.

Sweep netting consisted of walking within 10 m of a mist net, and sweeping the vegetation in five back-and-forward or up-and-down motions. At each sampling location, sweep netting was confined to a pre-determined subset of the available vegetation; which was sampled each week. The shrub vegetation we sampled was understory saltcedar (*Tamarix ramosissima*), Russian olive (*Eleagnus angustifolia*), New Mexican olive (*Florestiera neomexicana*), and four-winged saltbush (*Atriplex spp.*). When present, the herbaceous layer was also sampled; herbaceous vegetation was absent from the LFCC. Samples from sweeps were emptied into Ziplock™ freezer bags and stored in a freezer.

In conjunction with bird banding, the mist nets were checked from sunrise until net closure six hours later. Insects were counted, removed from the net, and identified. We expected to trap larger flying insects (dragonflies, large bees and beetles) that would not be effectively trapped by our other methods.

Number, size class (small: ≤ 6 mm; medium: > 6 to 12 mm; large: > 12 mm) and taxonomy (Order and Family) of arthropods were recorded. Parasitic wasps were difficult to identify and were classified to Order and Superfamily (Chalcidoidea), therefore, the richness of this family will be under-represented.

We compared yearly trends of arthropod numbers from willows of LFCC to those in other vegetation types. Our comparisons are based on numbers of arthropods adjusted by sampling effort for each of our trapping methods. Because of changes in sampling design among years, only the subset of traps that were used consistently were useful in assessing trend among years. One to three traps were consistently sampled over all years in each vegetation

grouping: LFCC willow (three traps), saltcedar (two traps), mixed cottonwood (two traps), and agricultural edge (one for sweeps and two or three for pitfalls or glueboards). Mist net sampling for insects ranged from two in the agricultural edge, five in the cottonwood and saltcedar, and eleven in the LFCC willow. We expressed relative abundance as number of arthropods caught per day that traps were open.

Vegetation Measurements. We measured vegetation characteristics in 0.04 ha circular plots surrounding mist nets along the LFCC and in the other habitats that were sampled. We estimated total shrub, overstory, grass and forbs, litter, and bare ground cover at each net. We also counted numbers of stems by DBH size class and species.

Point Count Transects. All five years of the study; we ran various numbers of point count transects. We attempted to do representative transects in the same habitats we were mist-netting. Unfortunately several of our transects were burned by the San Antonio fire of June 1996. The refuge asked us not to continue these transects as they intended to be working with heavy equipment to restore these sites. The point count transects were all 1 kilometer long and had six point count locations. The point counts were counted for 5 minutes each. Birds were also recorded between points. All birds were recorded by sight and sound. Behavior was noted also.

RESULTS AND DISCUSSION

Total Captures. In 1996, 1997, and 1998 combined, 132 species of birds were captured in the Bosque del Apache (Table 1) and 92 of these were captured along the LFCC (Table 2). The total number of bird captured in 1997 (n = 1734) was less than half the number banded in 1996 (n = 3751). Of the 1734 birds captured in 1997, 666 were captured in the spring and 1068 were captured in the fall. We captured about 20% fewer species in 1997 compared to 1996 (79 in 1997 and 101 in 1996). Fewer species were also captured in the spring (57) and fall (63) of 1997 than were captured in the spring (79) and fall (74) of 1996. As was true in 1996, Wilson's Warblers (*Wilsonia pusilla*) (see appendix 1) were by far the most common species captured (n = 418) in 1997 and they comprised a larger portion of the individuals captured than in 1996 (24% of captures in 1997 vs. 19% of captures in 1996). The greatest change in abundance between 1996 and 1997 was exhibited by Chipping Sparrows (*Spizella passerina*) which were the second most common species captured in 1996 (n = 298; 8% of all captures), but only 26 were caught in 1997 (< 2% of all captures). White-crowned sparrows (*Zonotrichia leucophrys*) were the 2nd most common species captured in 1997 (n = 167;10% of captures) and they were the 4th most common species in 1996 (n =244; 7 % of all captures). Total captures of Ruby-Crowned Kinglets (*Regulus calendula*) only dropped slightly from 1996 (n = 157) to 1997 (n = 145) which caused them to move from the 6th most common species in 1996 (4% of captures) to the 3rd most common species in 1997 (8% of captures). Finally captures of MacGillivray's Warblers (*Oporornis tolmiei*) dropped from 296 (8% of captures) in 1996 to 70 in 1997 (4 % of captures). While we did operate fewer nets in 1997 this only accounts for a small portion of the

decline (see below). When compared with previous years 1997 appears to be more of the norm and 1996 appears to be more unusual.

In 1998, 3721 individual birds were banded, of which 540 individual birds were banded in spring and 3181 individual birds were banded in fall. 1998 was very similar to 1996 in total captures although, the abundant seasons were reversed see (Figures 2a and 2b). It was comparable to 1996 also in the number of species captured by season; 61 in spring and 68 in fall. Once again Wilson's warbler (*Wilsonia pusilla*) were by far the most common species captured (n = 1438) and they comprised an incredible 39% of all captures. In 1998, Yellow warbler (*Dendroica petechia*) were second with (n = 277; 7% of all captures). This was their best year by far. White-crowned sparrows (*Zonotrichia leucophrys*) were third with (n = 257; 7% of all captures). Also Ruby-crowned kinglet (*Regulus calendula*) was similar to previous years (n = 124) and MacGillivray's warbler (*Oporornis tolmiei*) was in between the previous years (n = 106). The Chipping sparrow (*Spizella passerina*) made a comeback to 1996 levels (n = 117). These were the top seven species, see Table 1.

Habitat differences by year and season are shown for all five years of this study (Figs. 2a and 2b). Standardized capture rate fluctuated year to year but a few trends were discernable. The original coyote willow area had the highest capture rates every year and season. This area was used by many of the Neotropical migrant warblers in our study. The Low Flow area's capture rates were highest in the spring of 1996 for all springs and highest in fall 1998 for all falls. This was the same trend for the overall study area. The capture rates in the cottonwood and salt cedar areas were consistently low. The agricultural edge area was biased somewhat by the mowing of part of the area in 1996. It rebounded somewhat as it regrew the next two years. Also the timing of the arrival of the wintering sparrow species had a large effect on this fluctuating pattern.

Banding Effort. In 1996 we netted for 7,997 net hours in the spring and 13,085 net hours in the fall for a total of 21,092 net hours. The majority of this effort was concentrated on the LFCC (2,491 net-hours in spring and 4,673 net hours in fall) and in cottonwood (3,217 net hours in spring and 4,698 net hours in fall). Our overall netting effort in 1997 was very similar to that in 1996. We netted for 7691 net hours in the spring and 12938 net hours in the fall for a total of 20,629 net hours in 1997 which is 98% of our 1996 effort. A larger majority of our 1997 effort was focused on the LFCC (8,183 net hrs; 40% of total effort). Cottonwood and saltcedar habitats were the next most intensely banded sites with about 4,151 net hours each.

In 1998 our effort was somewhat reduced. We netted a total of 7,131 net hours in the spring and 10,679 net hours in the fall for a total of 17,810 net hours. As in previous years the LFCC comprised a large portion of our overall effort; 3297 net hours in spring (46 % of the total effort) and 4,794 net hours in the fall (45% of our total effort). Saltcedar had the next highest effort at 4,068 net hours and then cottonwoods with 2,915 net hours. The 1998 total was 84% of the 1996 effort. This difference reflected a large reduction in the amount of effort in the cottonwood area.

Capture rates. Overall capture rates in 1996 were 16.9 birds/100 net hours whereas in 1997 capture rates were only 8.4 birds per 100 net hours (Figs. 2a and 2b). So the decline in captures was not due to change in the amount of banding effort. The decline in capture rate was reflected in the vast majority of species captured in both the spring and the fall. Of the 20 species with at least 20 captures in the spring of either 1996 or 1997, 16 had lower capture rates in 1997. Of these 20 species, only Willow Flycatchers, Yellow Warblers (*Dendroica petechia*), Ruby-crowned Kinglets, and White-crowned Sparrows increased in abundance from spring 1996 to spring 1997. Three of the five species with the largest declines in spring capture rates were warblers. Declines in capture rate were evident in an even higher fraction of common species fall. Of the most 25 common species, 22 had lower capture rates in fall 1997 than in fall 1996. Of these 25 species, the only ones whose capture rates increased from fall 1996 to fall 1997 were Common Yellowthroats (*Geothylpis trichas*), Brewer's Sparrows (*Spizella breweri*) and Blue Grosbeaks (*Guiraca caerulea*). Interestingly, the 5 species with the greatest declines in abundance between fall 1996 and 1997 were sparrows. Cottonwood habitats have been fairly stable over the period of the study.

In 1998, the overall capture rate was the highest for the three years at 20.8 birds/100 net hours and 7.0 birds/100 net hours in the spring and 29.8 birds/100 net hours in the fall. This fall, we captured large numbers of warblers (Wilson's, Yellow, Orange-crowned) and sparrows (White-crowned, Chipping, Brewer's and Song) see Table 1 and 2.

During the three year period 1996-1998, we computed the relative abundance by capture rate rankings (Table 3a and b). Wilson's warbler was first ranked every season. In the spring, next were Dusky Flycatcher, Common Yellowthroat, Yellow Warbler, White-crowned Sparrow, MacGilvray's Warbler and Brewer's Sparrow. In the fall, after Wilson's Warbler was White-crowned Sparrow, Ruby-crowned Kinglet, Yellow Warbler, MacGilvray's Warbler and Chipping Sparrow. See (Figs. 2a and 2b) for relative capture rates by habitat group over the period of the whole five year study.

Willow Flycatcher. Analysis by Stein's formula indicates that 88.5 % of the birds that we have identified as Willow Flycatchers can be confirmed as Willow Flycatchers rather than Alder Flycatchers (Figure 3). Several factors indicate that birds whose species could not be confirmed on the basis of Stein's formula were also Willow Flycatchers. First, this formula only separates 90% of birds known to be Willow Flycatchers (Stein 1963). Thus a pure sample of Willow flycatchers would not have more separation than our sample. Second, the presence of an Alder Flycatcher has never been confirmed in New Mexico (Williams 1997). Third, young Willow Flycatchers have been shown to be less distinguishable from Alder Flycatchers on the basis of Steins formula (Hussell 1991). For these reasons we are confident that our identification of these birds as Willow Flycatchers is accurate in the vast majority of cases.

A total of 152 Willow Flycatchers have been captured in the 5 years of the study and 28 of these were categorized as belonging to the endangered Southwestern subspecies; see (Table 1 and 2). A total of 54 Willow Flycatchers were caught along the LFCC of which 5 were categorized as southwestern subspecies during the 3 years this area was studied. It appears that

the primary characteristic that we used to categorize flycatchers to subspecies was back color (Table 4).

Principal Components analysis of tail length, wing length, bill length, wing formula, tarsus length did not reveal a single or combination of morphological features that readily distinguishes among the subspecies of Willow Flycatchers. Thus, the accuracy with which subspecies assessment can be made in the field remains unclear.

Because of the low number of captures of Southwestern Willow Flycatchers it is impossible for us to make any generalizations about habitat use of this subspecies that are distinct from the rest of the species. The capture rate of Willow Flycatchers declined from 1996 (2.4 birds/1000 net hours) to 1997 (2.0 birds/1000 net hours) to 1998 (1.6 birds/1000 net hours). The greatest number of Willow Flycatchers were consistently captured in the LFCC habitat although capture effect appeared every year of the three year study period. We looked for spatial distribution factors in rates were higher in the willow habitat (Table 1 and 2). To assess the relative habitat use of Willow Flycatchers we compared the percent of birds captured in each habitat to the percent of banding effort (net hours) devoted to each habitat. In each season except fall 1996 and 1998 a larger percentage of Willow Flycatchers were captured along the LFCC than the percent effort devoted to that habitat. This indicates that Willow Flycatchers were relatively abundant in this habitat. This pattern was also evident in the willow habitats in all seasons. The saltcedar habitat in the fall of 1997 and the spring of 1996 had a larger percentage Willow Flycatchers captured than effort but all the other season were the reverse. Both the agricultural edge and the cottonwood habitats consistently captured fewer Willow Flycatchers than the amount of effort expended (Figures 4a and 4b).

Willow Flycatcher migration peaked in the 1st week of June during the spring and in the 1st week of August in the fall (Figure 5). The peak of migration appears to be more narrow in the spring than in the fall. There does not appear to be a clear difference among habitats in the timing of migration. The majority of birds had little fat as indicated by fat scores of zero or one (Figure 6). Again there were no obvious differences in fat scores among birds captured in different habitats. This lack of pattern also was apparent in the mass of birds captured in different habitats (Table 5).

Vegetation Cover. The LFCC had vegetative characteristics similar to those of the Willow habitat that exists along an irrigation ditch in the refuge (Table 6). These willow stands varied in height from 6 to 15 feet in height. While these habitats had similar shrub cover, the number of stems at the LFCC was double that at the Willow Site. We speculate that the high stem density at the LFCC may result from more frequent mowing. It is unclear at this time whether this characteristic has any significant effect on bird use of this site. The densest shrub habitat was saltcedar and this habitat also had the most bareground. Only the cottonwood and agricultural edge habitats had overstory cover.

Mowing of the willow habitat was not a controlled part of the study as planned. The Low Flow willow strip was not mowed as planned. It rebounded quickly from it's last mowing in 1995. The Low Flow willow strip grew rapidly each spring, but then suffered winter die-back. So, average height of this patch only increased about 1-2' per year during our study period. The effect on bird captures of this growth needs more study. We could not separate out this local effect from the larger regional patterns which primarily drove bird capture numbers. The original willow area was mowed partially in the late fall of 1996 and 1997. A ten foot wide strip was mowed between the ditch and the rest of the patch. This area sprouted back both springs to about four foot tall which masked the effects. The unmowed portion stay an average of 12-15' in height. We list the coverages of mature willow in (Table 6). The noticeable effects on bird capture numbers were in the spring of 1997 after the first mowing. Net areas SW1 and SW4 with much reduced willow coverages, captured far fewer birds, see (Figs. 7a and 7b). This effect continued for SW4 in that fall. The sprouting of the mowed area in the SW1 area seemed to limit the effect in this area. Overall this mowing regime did not have a negative effect on bird use unless the majority of the cover was removed around a net area.

Point Count Transects. Results of all five years of transects were analyzed. These are displayed by habitat types and season (Figs. 8 a and 8b). As stated before some of the transects were discontinued in June of 1996. One new transect was added along the LFCC in 1998. The relative importance of the habitats in the spring were: willow, agricultural edge, cottonwood, saltcedar, mesquite and low flow. In the fall the order changed a little: agricultural edge, willow, cottonwood, mesquite, saltcedar and low flow. We think the sift to the agricultural edge in the fall has to do with the presence of crops in the adjacent fields. The willow habitat was very important which corresponds to our mist-netting results. The low numbers in the one year of sampling at the low flow habitat is hard to explain because the capture rates in the mist-netting there that year were very high.

Spatial Distribution Factors. This study was iniated with the intention of looking at regional patterns of habitat use by migratory land birds in the Middle Rio Grande River riparian zones. With that in mind; digital mapping of the study area was acquired from the Bosque del Apache NWR. This was refined somewhat for our study area map (Fig. 1). We also obtained portions of the Middle Rio Grande Riparian Mapping Project from the USFWS. This map is still in the draft stage. We first looked at the microsite differences and discovered an interesting microsite difference on the Low Flow Conveyance channel area. There appears to be a strong edge effect in the vicinity of LF11-LF13 and LF2 (Fig 9 a and 9b). These areas are adjacent to cleared areas next to two ditches see Figure 1. It appears birds, particularly warblers, could be moving across from the edges and breaks in the cottonwood and salt cedar patches over to the willows (Figs. 9c and 9d). This effect may also exist for Willow Flycatchers (Figs. 9e and 9f). This edge pattern appeared every year of the three year study period. We looked for spatial effects in the other areas but only found a weak agricultural edge effect related to the crops in the different fields. The crops were rotated by the Bosque del Apache NWR. More data is needed to be able to quantify this effect. The individual bird species preferences for a particular habitat overrode the spatial distribution of all the habitat groups in our small area generally.

We used the larger scale mapping to try and expand our study's results into the larger regional context. We compared our percentage of captures against the percentage effort in the different habitat groups (Figure 10). We then compared this to the percentages of these habitat groups in the larger areas. This comparison showed that the birds captured to effort expended in the cottonwood and salt cedar was low; meaning these habitats were less utilized by the migrating land birds. The willow and saltbush habitat groups had a much higher percentage of birds to effort; meaning that these habitats were more heavily utilized than the other two habitat groups studied; particularly the willow. This situation was then compared to the three larger areas. These are the total riparian vegetation within the Bosque del Apache NWR; the San Acacia reach of the Middle Rio Grande (the Bosque del Apache was a subset of this) and the Belen Reach of the Middle Rio Grande. Willow and saltbush habitats made up a small % of the area in these reaches. Thus, these habitats may be a regionally important feature for migrants. These coyote willow areas exist to a large degree along water conveyance structures. These are periodically mowed which contributes to the low availability of this habitat group.

The effects from the San Antonio fire were looked at also. The fire burned 22.6% of the riparian area within the Bosque del Apache NWR. It burned a much higher percentage of the older cottonwood patches proportionally (Table 7). There was a noticeable drop off in the birds that breed within the vicinity of the fire captured the two falls (1997 and 1998); after the fire, particularly those nesting in the cottonwood habitat.

Arthropod sampling. We captured 28 Orders and 169 Families of arthropods in all our sampling collections during spring and fall 1996 to 1998 (Appendix 2). Pitfalls were designed to trap ground traveling arthropods, and the following ground-dwelling Orders were collected only in pitfalls: bristletails, scorpion flies, termites (wingless), sun spiders (Solifugae), and puedoscorpions. Isopods, another ground-dwelling order, were plentiful in pitfalls, but were also occasionally found in shrub sweeps in the fall. Seventy eight percent of individuals trapped were Hymenoptera, which were comprised largely of ants trapped in agricultural edge (> 90%). When discounting the ants, springtails made up 85% of trapped individuals and isopods ranked second (9%). Additional Orders, in descending order with the numerically dominant families in parentheses, were: Diptera (muscid flies), Coleoptera (ground and darkling beetles), Araneae (wolf and jumping spiders), and Orthoptera (crickets).

Glueboards were used to capture aerial insects and mobile foliage arthropods. Forty nine percent were Diptera and 77% of them were families of small aerial swarmers (hump-backed flies, midges, dark-winged fungus gnats, long-legged flies, dance flies, and fungus flies). Thysanoptera (thrips) were second in numerical dominance (17%). Thirteen percent were Hymenoptera consisting of minute parasitic wasps (53% of the wasps were Chalcidoidea), and braconid wasps and sweat bees (each 9%). Homoptera comprised 13% of the individuals with leafhoppers (54%) and aphids (42%) making up the bulk of their family composition.

We used sweep netting to add to our collections of foliage insects. Samples taken in shrubs yielded a large proportion of Homoptera (46%), 88% of which were leafhoppers. Twenty percent were Diptera (61% midges and 9% of dance flies and frit flies) and 15% were Hymenoptera (72% ants). Sweeps in the herbaceous ground cover gleaned 39% Hemiptera (67% seed bugs) and 26% Homoptera (60% leafhoppers).

Because of the mesh size, large insects (> 12 mm) were found tangled in our mist nets. Discounting one large swarm of honey bees (2000 individuals), forty percent of the insects caught in the mist nets were Orthoptera (97% short-horned grasshoppers). Ranking second were Coleoptera (33% metallic wood-boring beetles and 31% scarab beetles). Homoptera (>95% cicadas) and Odonata (dragonflies and damselflies) each comprised 8% of the captures.

We were concerned about the variability caused when examining different trap locations; therefore, we compared traps used in all three years. These traps showed that total arthropod numbers increased over the years in the spring and fall for most sampling methods (Table 8). These trends were similar to those found in the collections from all traps; but we continued to examine trends using only the standardized subset of traps. Arthropod numbers collected by glueboards and sweeps (primarily small swarming flies) doubled or tripled in 1998 compared to the previous year. Numbers in pitfalls, highly influenced by the quantity of ants, increased by a factor of ten in the spring and by five in the fall. The large increase in spring mist-netted insects in 1998 was due to one swarm of bees (Table 8). For raw abundances of arthropods captured in LFCC willow from all sampling methods, see Appendices 3 and 4. See Appendices 5 and 6 for raw abundance of all sampling in the study area.

In 1996 and 1997, we compared LFCC willow with willow that retained a more natural substrate. LFCC willows grew among piles of artificially placed rocks that inhibited herbaceous growth. Otherwise, both areas were narrow bands of willow growing along water conveyance channels. The more natural willow supported as many or more arthropods than LFCC willows for both spring and fall (Figure 11).

Pitfalls in the agriculture edge were overwhelmed with ants, which increased in number in 1998. For clarity, we omitted ants from the analysis. Spring pitfalls trapped as many or slightly more arthropods in the LFCC than in other areas in 1996, but decreased in captures the following two years. Saltcedar pitfall captures increased over the years (Figure 12). In the fall, LFCC captures were similar in 1996 and 1997. In 1998, an explosion of springtails appeared in the agricultural edge and to a lesser degree in the cottonwood (Figure 13).

Glueboard captures in the LFCC were greater than in other areas in spring 1998, but this pattern was not evident in 1996 or 1997. LFCC glueboards trapped more insects than saltcedar in all years (Figure 14). There was no trend in fall numbers of arthropods among vegetation types and years (Figure 15). Spring sweeps in the shrub layer captured more insects in LFCC willows than other vegetation types, but not in the fall (Figure 16). The increase in LFCC insect numbers in 1998 was due to an abundance of flies, leafhoppers, and wasps and bees. Mist net captures in LFCC willow were not much different from saltcedar (Figure 17) in spring or fall. Numbers of insects increased noticeably in 1998 in the agriculture edge and cottonwood areas as numbers of grasshoppers doubled.

Southwestern Willow Flycatcher diet has been studied from fecal samples collected at sites in Arizona and western Colorado during the breeding season (Drost et al. 1998). Approximately half of the prey items were flies (Diptera), bees and wasps (Hymenoptera), and true bugs (Hemiptera). These orders are included in the diets of many insectivores such as wood warblers (Bent 1953). Trends in the abundance of these orders trapped in our vegetation types were examined from glueboard captures. Each year we captured fewer Diptera (Figure 18) and fewer Hymenoptera (Figure 19) in saltcedar in spring and fall, than other vegetation types.

Yearly numbers of Hymenoptera in LFCC ranked high (Figure 19). In some years, LFCC traps captured more Hemiptera (true bugs) than other vegetation types (Figure 20).

Preferred prey of willow flycatchers and other insectivorous birds migrating through LFCC willow are present. LFCC willows rank high in the numbers of total arthropods and in preferred prey compared to exotic saltcedar and other native vegetation in the vicinity.

RECOMMENDATIONS FOR THE FUTURE

It is clear form our data that Willow Flycatchers and other migrant birds are using the LFCC as a stopover habitat during both the spring and the fall. By intensely studying the LFCC we have been able to document both yearly variation in habitat use and the progression of change that follows rest from mowing. The fairly well developed willow stands that have developed in the absence of mowing since 1995 indicates that a rotational mowing system may be a viable means for providing habitat for migrant birds while not compromising the function of the LFCC. To understand the compatibility of these uses at a broad scale, however, it is necessary to have a broad view of the conditions that exist on the LFCC. That is our study has been useful in documenting the potential to use rotational mowing to benefit migrant birds, but to understand how much of that potential can be realized we need to sample a broader portion of the LFCC. Also the relative importance of edge effect and microsites along the LFCC should be investigated. The more important microsites could be put on a longer mowing rotation.

Here are some recommendations for the areas other than the LFCC:

1.) Manage edge strips between agricultural field for song birds by allowing vegetation to mature.

2.) Plant sunflowers in some of the agricultural fields for migrating songbirds.

3.) Maintain brush piles for songbird cover next to open areas.

4.) Maintain mowing regime of willow along ditches in refuge and where feasible retain willow vegetation associated with conveyance structures by either lengthening mowing cycles or mowing only a limited portion of the vegetation.

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List of Figures, Tables and Appendices.

FIGURES

Figure 1. Study Site Map and Legend.

Figure 2a. Spring Bird Capture Rates by Habitat.

Figure 2b. Fall Bird Capture Rates by Habitat.

Figure 3. Willow Flycatcher Bill Length Plotted by Stein's Formula.

Figure 4a. Spring Relative Abundance of Willow Flycatchers by Habitat and Effort.

Figure 4b. Fall Relative Abundance of Willow Flycatchers by Habitat and Effort.

Figure 5. Timing of Willow Flycatcher Migration.

Figure 6. Fat Scores of Willow Flycatchers by Habitat.

Figure 7a. Spring Effects of Willow Mowing on Bird Numbers and Diversity.

Figure 7b. Fall Effects of Willow Mowing on Bird Numbers and Diversity.

Figure 8a. Spring Habitat Use Average Number of Birds Counted from Point Count Transects.

Figure 8b. Fall Habitat Use Average Number of Birds Counted from Point Count Transects.

Figure 9a. Spring Spatial Distribution of Migrating Songbirds along the LFCC. (Figure 9 Nets were spaced at 100 meter intervals starting with LF2 at the refuge's north boundary and running south).

Figure 9b. Fall Spatial Distribution of Migrating Songbirds along the LFCC.

Figure 9c. Spring Spatial Distribution of Migrating Warblers along the LFCC.

Figure 9d. Fall Spatial Distribution of Migrating Warblers along the LFCC.

Figure 9e. Spring Spatial Distribution of Migrating Willow Flycatchers along the LFCC.

Figure 9f. Fall Spatial Distribution of Migrating Willow Flycatchers along the LFCC.

Figure 10. Bird Captures by Habitat and Effort Compared to the Vegetation in Larger Areas of the Middle Rio Grande Riparian Forests.

Figure 11. Arthropod Numbers from Glueboard Sampling in Willows.

Figure 12. Spring Arthropod Numbers using Pitfall Trap Sampling.

Figure 13. Fall Arthropod Numbers using Pitfall Trap Sampling.

Figure 14. Spring Arthropod Numbers using Glueboard Sampling.

Figure 15. Fall Arthropod Numbers using Glueboard Sampling.

Figure 16. Spring and Fall Arthropod Numbers Using Shrub-Sweep Sampling.

Figure 17. Spring and Fall Arthropod Numbers Using Mistnet Sampling.

Figure 18. Diptera (flies) Numbers Captured on Glueboards.

Figure 19. Hymenoptera (bees and wasps) Numbers Captured on Glueboards.

Figure 20. Hemiptera (true bugs) Numbers Captured on Glueboards.

TABLES

Table 1. Numbers of Birds Mistnetted during 5 Year Migration Study Period.

Table 2. Numbers of Birds Mistnetted along LFCC during 3 Year Study Period.

Table 3a. Spring Relative Abundance of Migrating Landbirds.

Table 3b. Fall Relative Abundance of Migrating Landbirds.

Table 4. Back Colors of captured Willow Flycatchers.

Table 5. Mean Sizes of captured Willow Flycatchers.

Table 6. Measurements of Vegetative Cover.

Table 7. Effects of San Antonio Fire on Riparian Vegetation within Bosque del Apache NWR.

Table 8. Yearly and Seasonal Trends in Arthropod Numbers.

APPENDICES

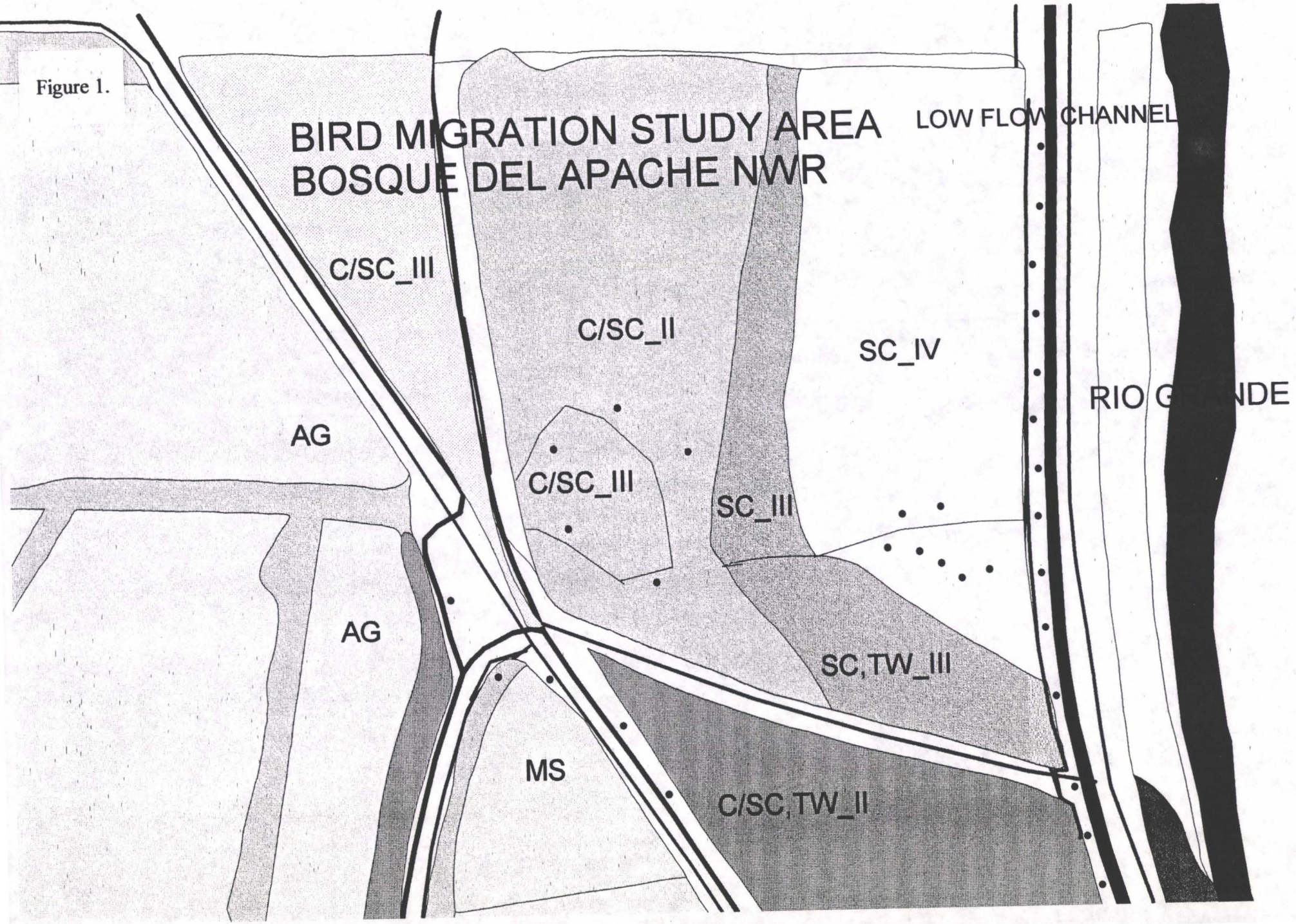
Appendix 1. Bird Species Names of those Encountered during Migration Study.

Appendix 2. Insect Species Names of those Encountered during Migration Study.

Appendix 3. Yearly Comparison of Arthropods Captured in Spring along LFCC.

Appendix 4. Yearly Comparison of Arthropods Captured in Fall along LFCC.

Figure 1.


BIRD MIGRATION STUDY AREA
BOSQUE DEL APACHE NWR
LOW FLOW CHANNEL
C/SC_III
C/SC_II
SC_IV
RIO G NDE
AG
C/SC_III
SC_III
AG
SC,TW_III
MS
C/SC,TW_II

LEGEND FOR FIGURE 1 BIRD MIGRATION STUDY 1994-1998
STUDY SITE MAP AT BOSQUE DEL APACHE NWR
ROCKY MOUNTAIN RESEARCH STATION

C/SC	COTTONWOOD/SALT CEDAR
C/SC,TW	COTTONWOOD/SALT CEDAR, GOODING WILLOW
SC	SALT CEDAR
SC,TW	SALT CEDAR, GOODING WILLOW
AG	AGRICULTURAL FIELD
MS	MOIST SOILS UNIT
II	STRUCTURE 2*
III	STRUCTURE 3*
IV	STRUCTURE 4*
o	NET AREAS
	ROADS
	DITCHES AND RIVER

* STRUCTURE CLASSES AS DESCRIBED BY HINK AND OHMART 1984.

FIGURE 2A BIRD MIGRATION STUDY USFS RESEARCH
SPRING CAPTURE RATES BY HABITAT SUBAREAS

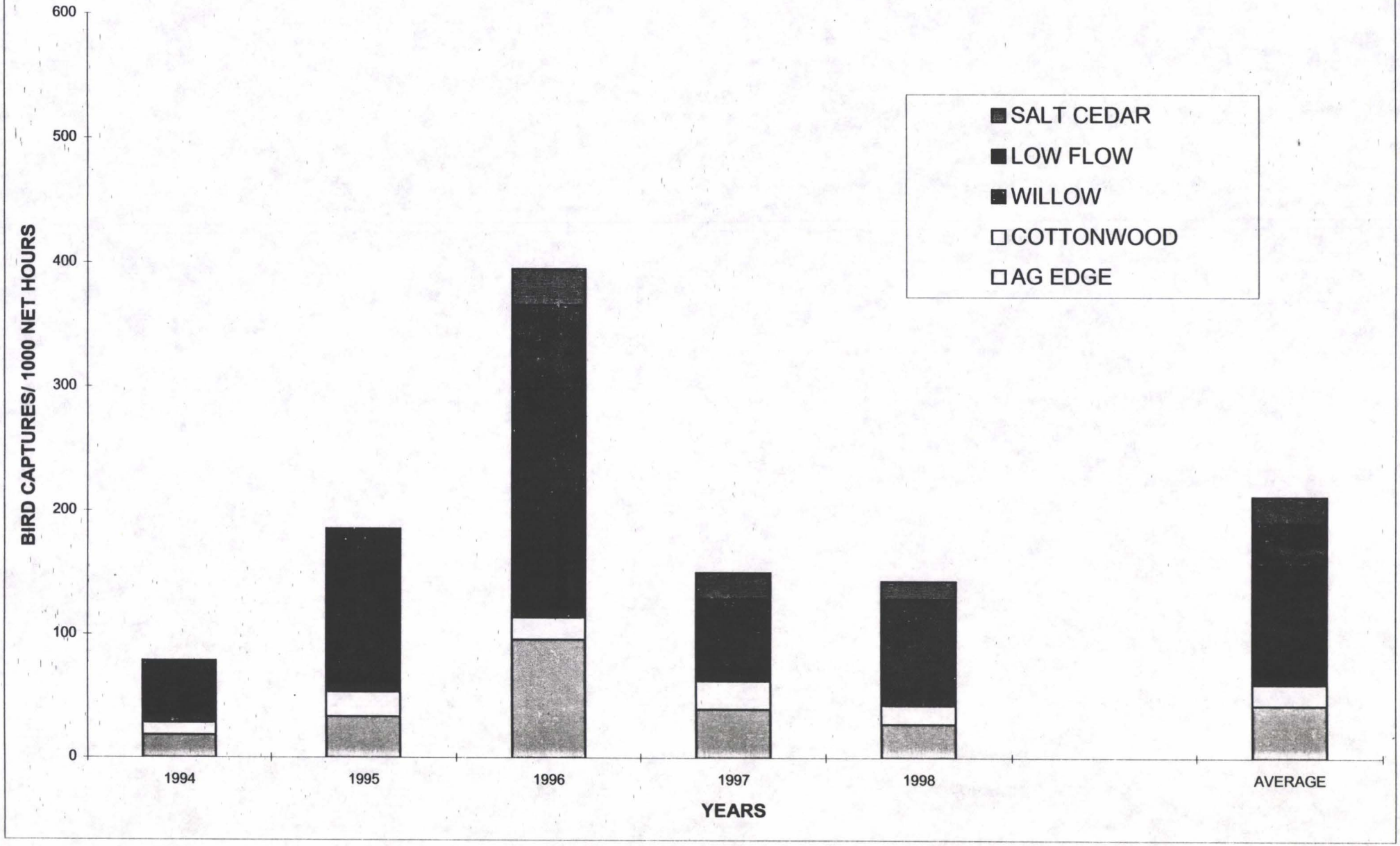
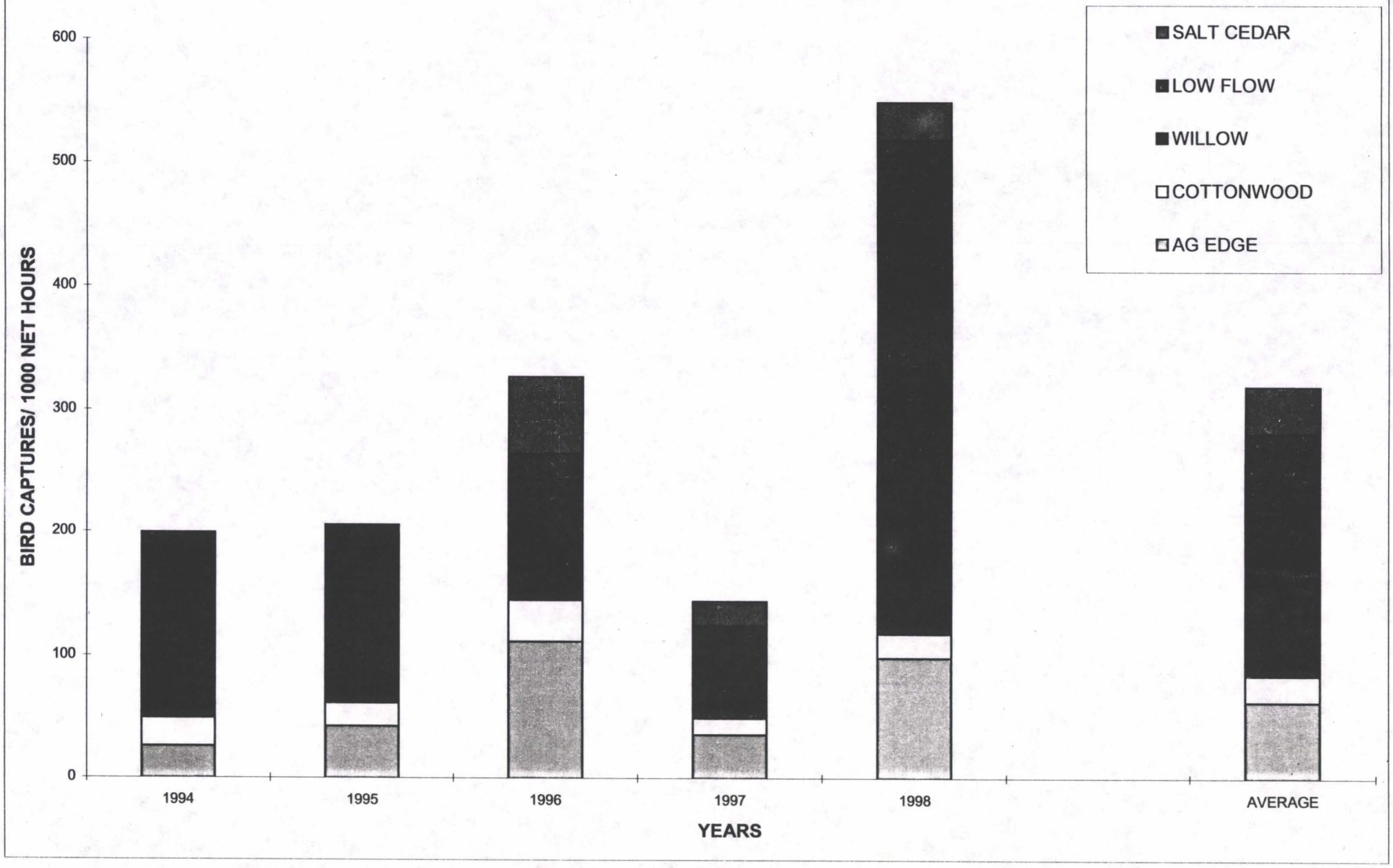


FIGURE 2B BIRD MIGRATION STUDY USFS RESEARCH
FALL CAPTURE RATES BY HABITAT SUBAREA



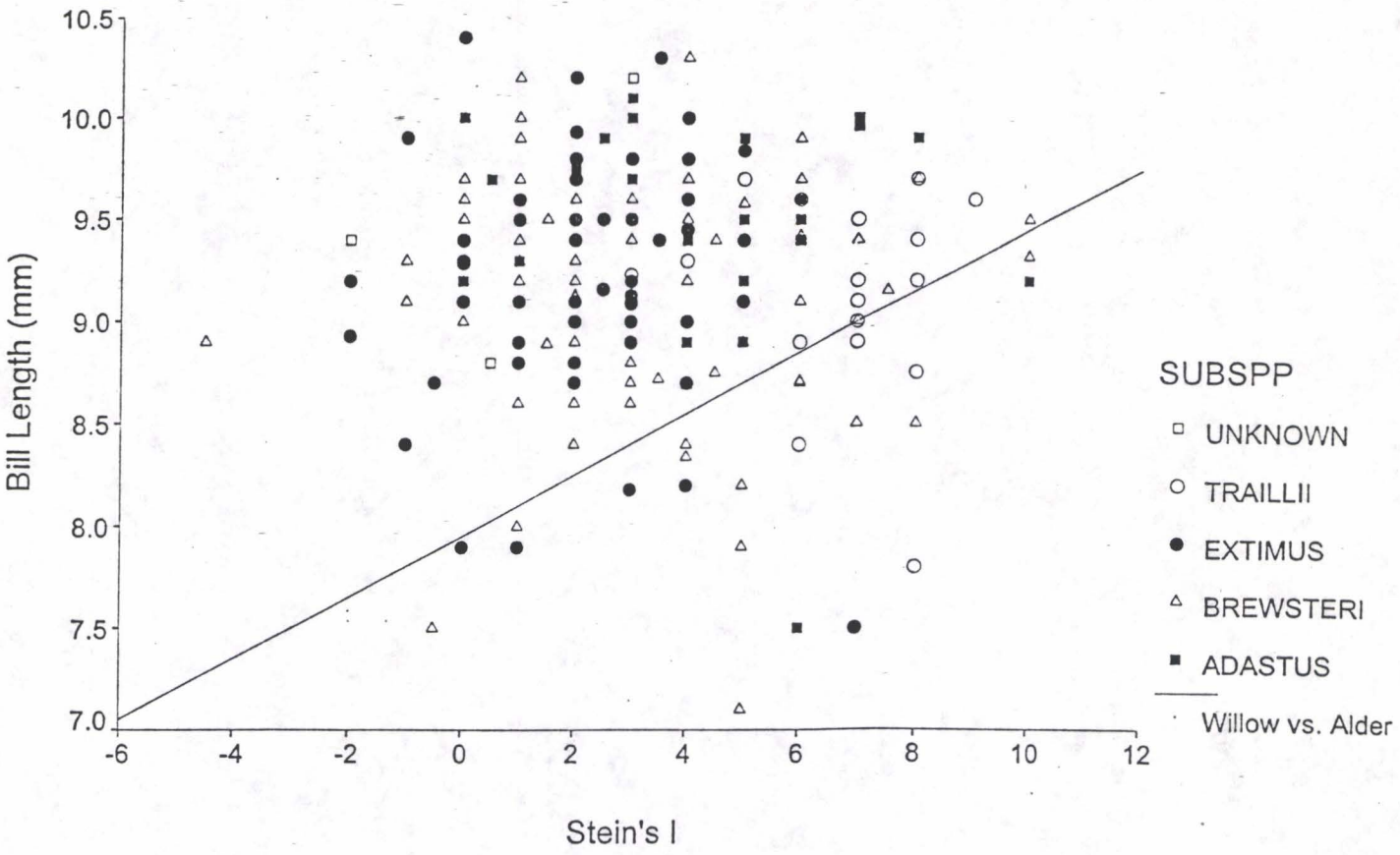


FIGURE 3.

Bill length plotted by Stein's I [(length of longest primary - length of the 6th primary) - (length of the 5th primary - length of the 10th primary)]. The line is described by the equation: bill length = 7.95 + 0.15I. Stein (1963) found that this line seperated 91% of known (by song) Willow (*Empidonax trallii*) and Alder Flycatchers (*E. alnorum*). Stein reported that about 90% of points above the line were Willow flycatchers and about 90% of the points below the line were Alder Flycatchers. So, a pure sample of Willow Flycatchers would be expected to have 90% the points above the line and 10% below. In reality this predictive ability is probably lower because, in general, regression lines more accurately describe the data that were used to develop them than independent data used to test them. That 88.5% of the points in the figure lie on or above the line sugessts strongly that the vast majority of birds captured during migration in the Middle Rio Grande Valley are Willow Flycatchers..

FIGURE 4A RELATIVE ABUNDANCE OF WILLOW FLYCATCHER DURING SPRING MIGRATION BOSQUE DEL APACHE NWR 1994-1998 BIRD MIGRATION STUDY USFS RESEARCH

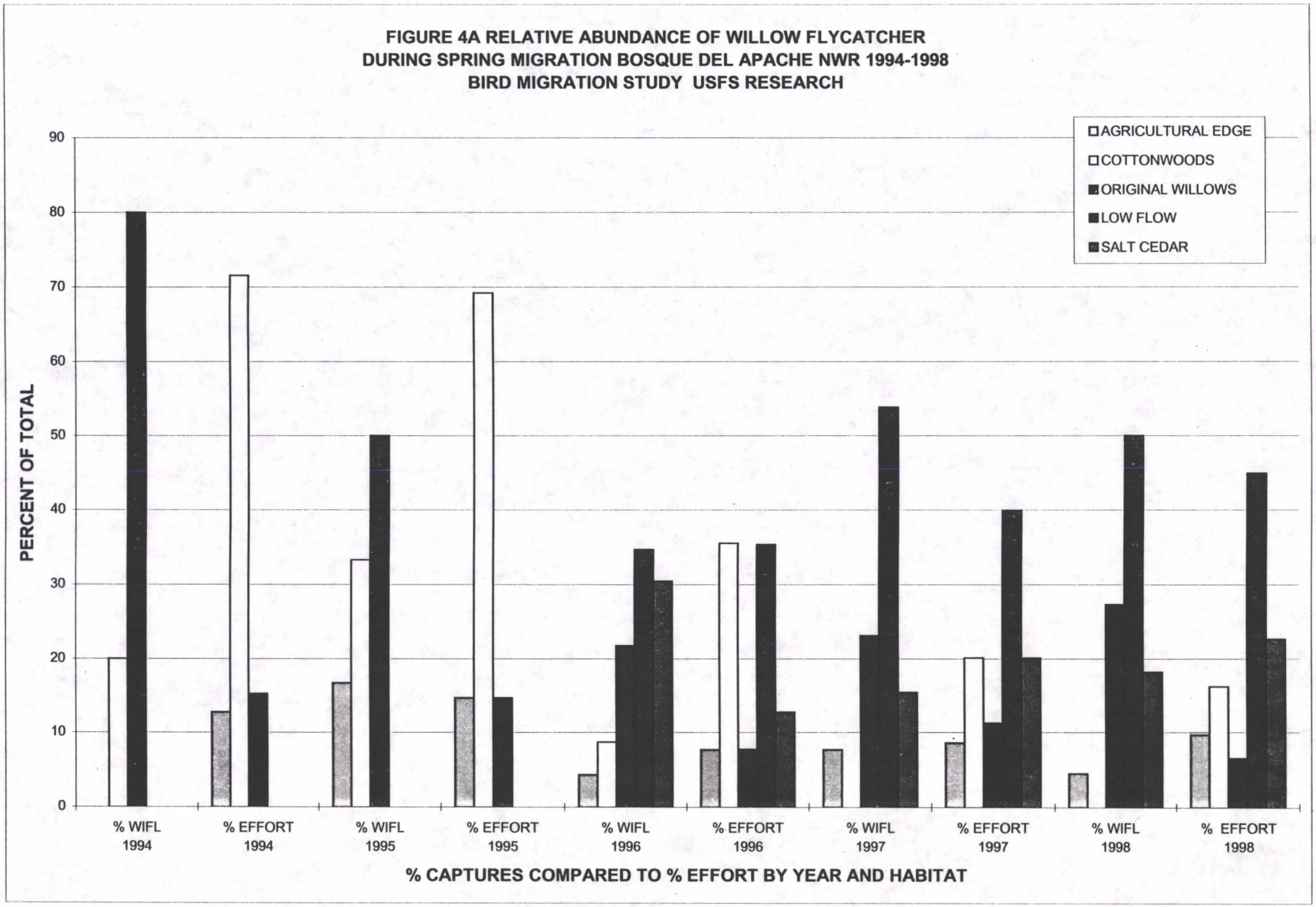


FIGURE 4B RELATIVE ABUNDANCE OF WILLOW FLYCATCHER DURING FALL MIGRATION BOSQUE DEL APACHE NWR 1994-1998 BIRD MIGRATION STUDY USFS RESEARCH

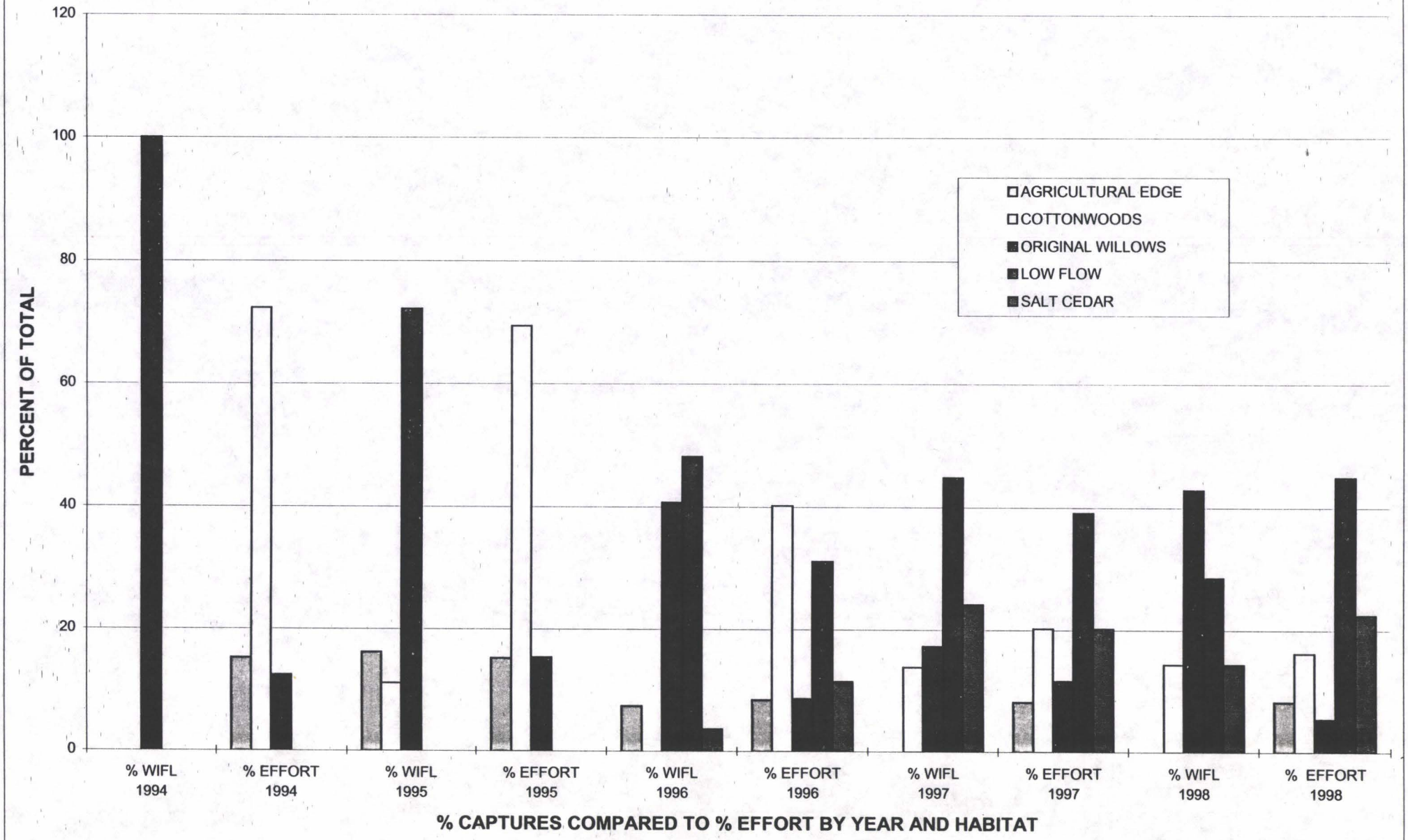
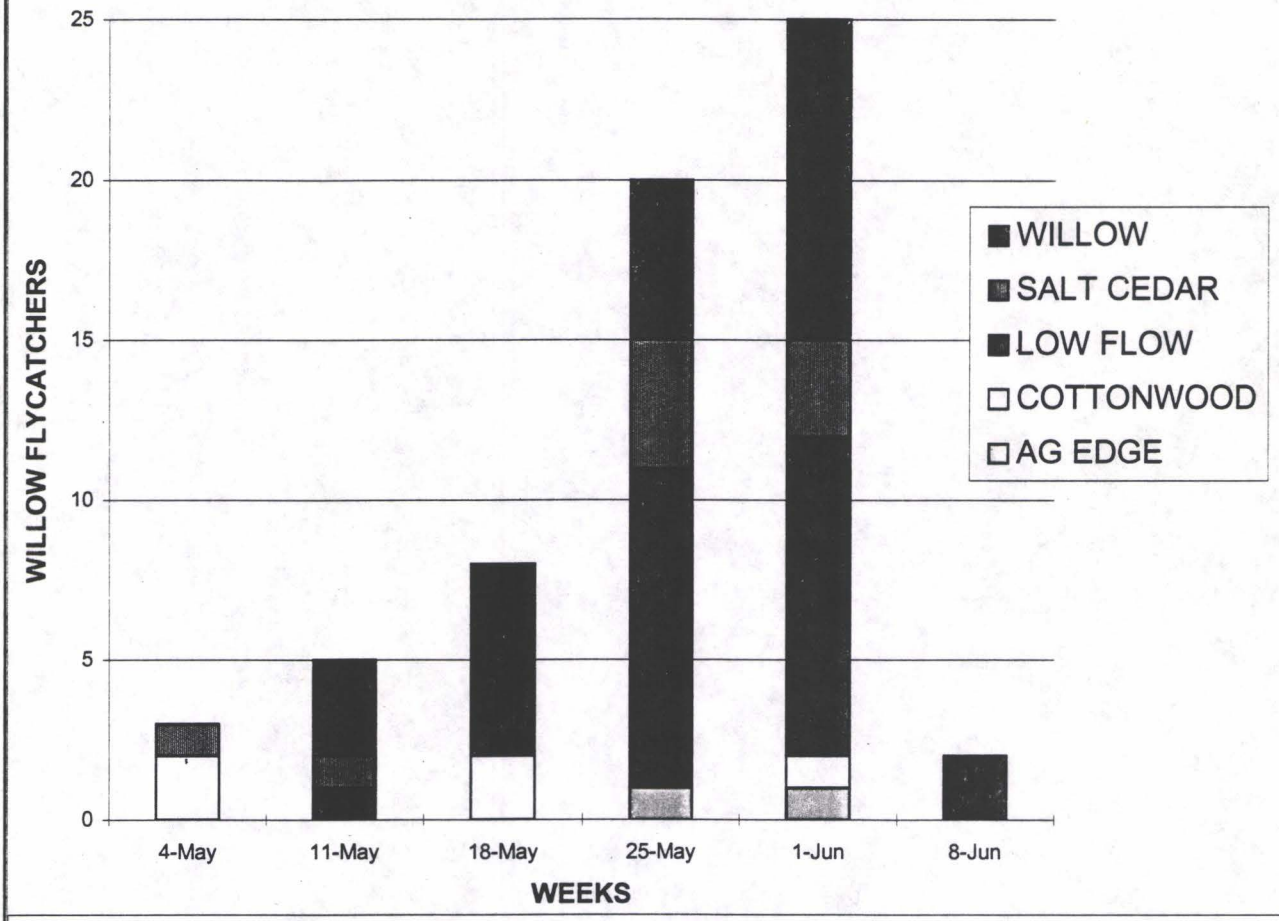


FIGURE 5 TIMING OF WILLOW FLYCATCHER MIGRATION DURING SPRING MIGRATION BOSQUE DEL APACHE NWR 1996-1998



TIMING OF WILLOW FLYCATCHER MIGRATION DURING FALL MIGRATION BOSQUE DEL APACHE NWR 1996-1998

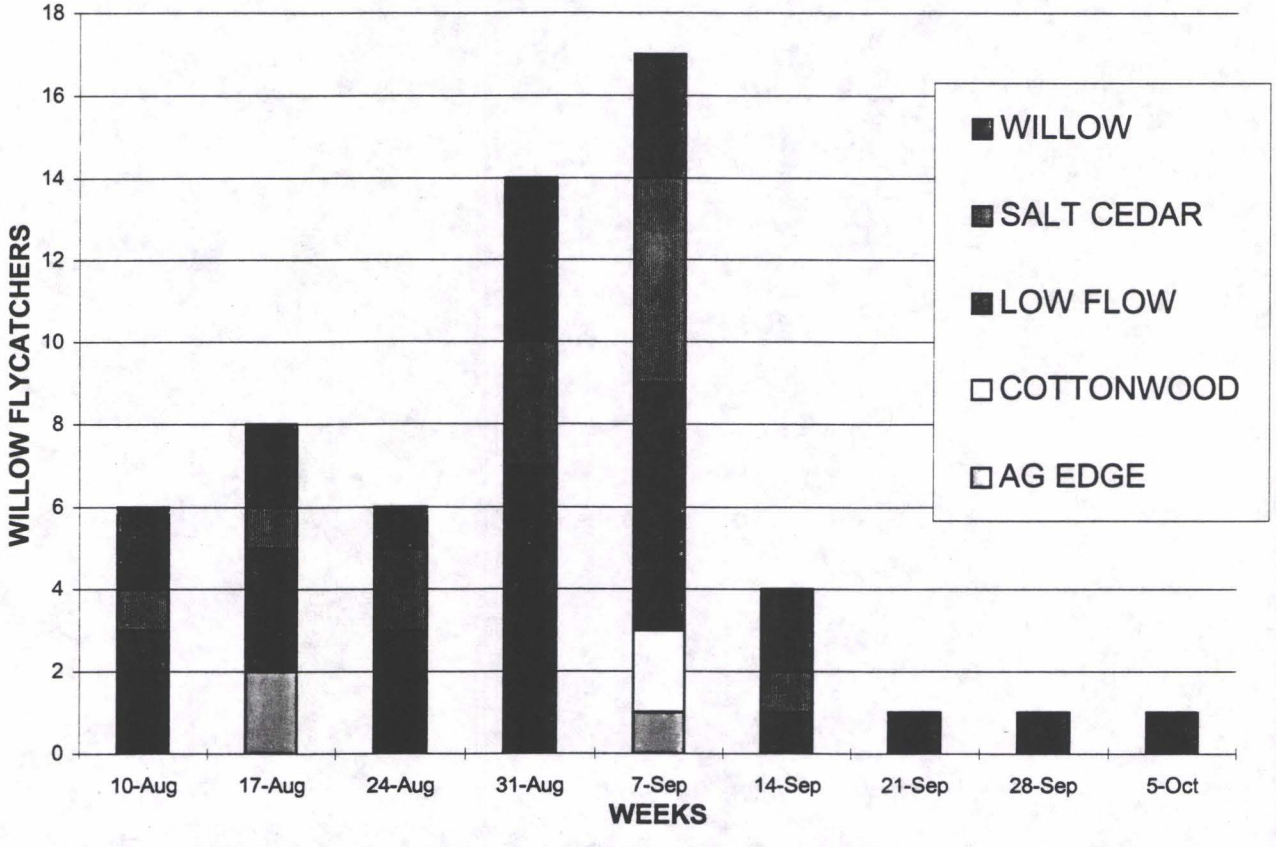


FIGURE 6 FAT SCORES OF WILLOW FLYCATCHERS
SPRING MIGRATION BOSQUE DEL APACHE NWR 1996-1998

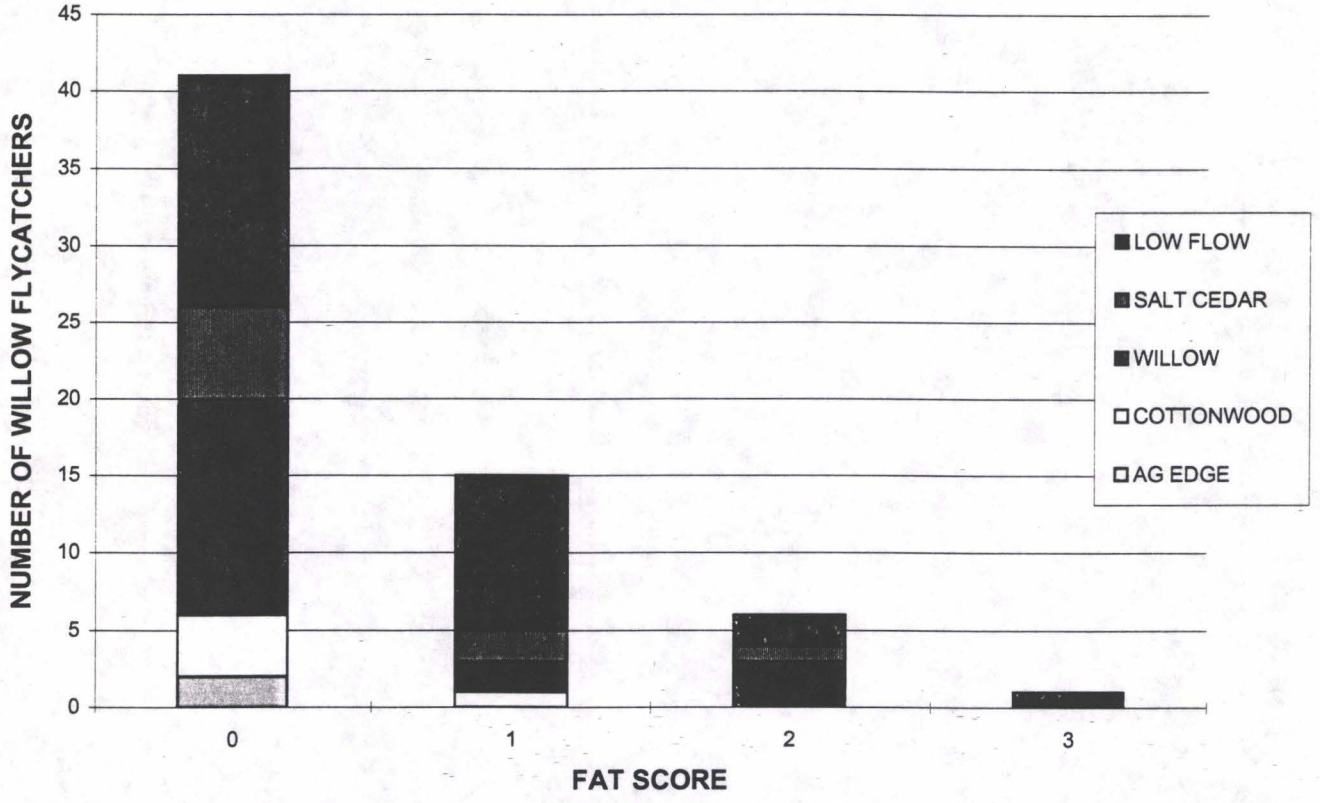
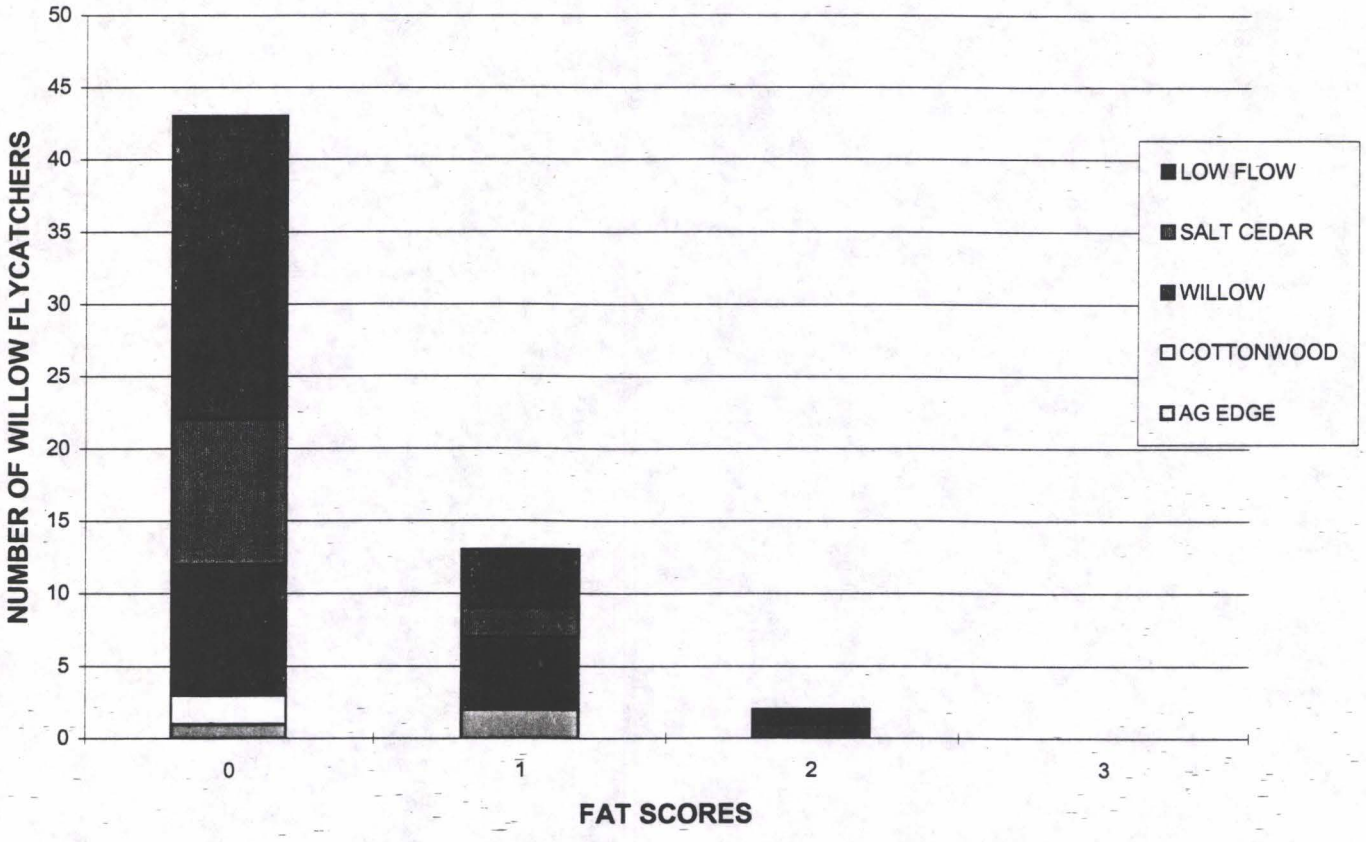


FIGURE 6 FAT SCORES OF WILLOW FLYCATCHERS DURING FALL MIGRATION



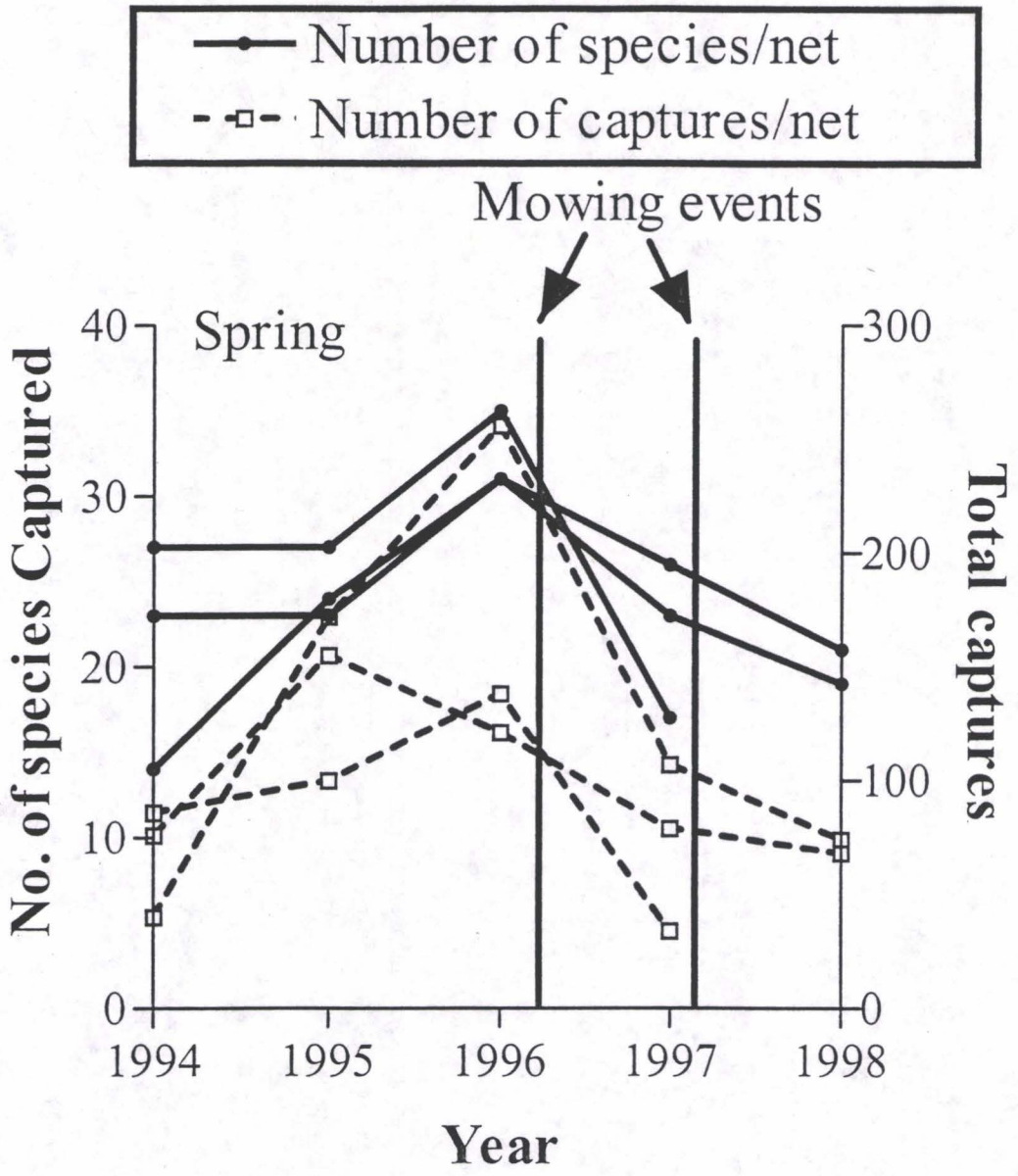


Figure 7a. Effects of mowing on the number of species and indivduals captured during spring at three nets in willow vegetation in the Bosque del Apache NWR. Mowing reduced the average willow cover from 50% to 30 % .

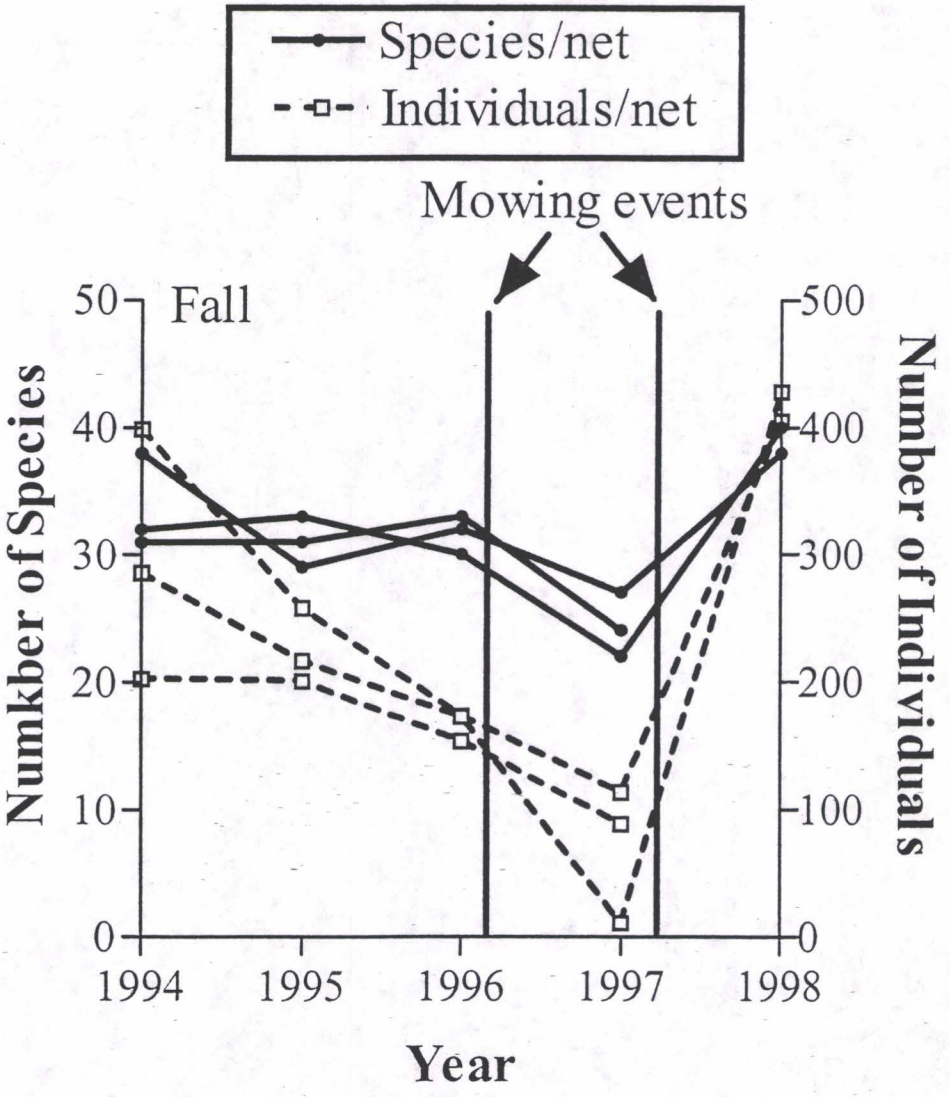


Figure 7b. Effects of mowing on the number of species and indivduals captured during fall at three nets in willow vegetation in the Bosque del Apache NWR. Mowing reduced the average willow cover from 50% to 30 % .

FIGURE 8a AVERAGE HABITAT USE FROM POINT COUNT TRANSECTS SPRING 1994-1998

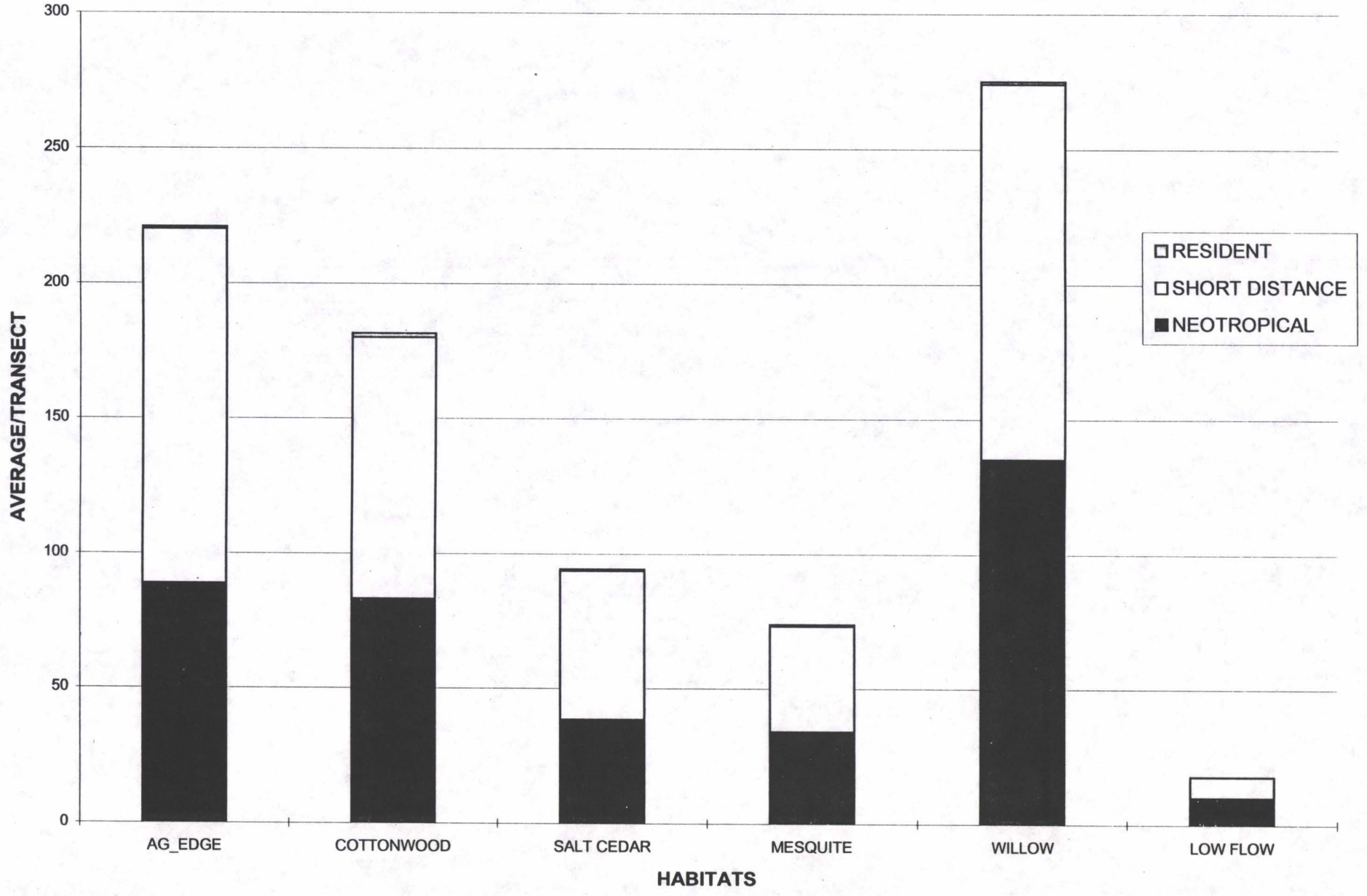


FIGURE 8b AVERAGE HABITAT USE FROM POINT COUNT TRANSECTS FALL 1994-1998

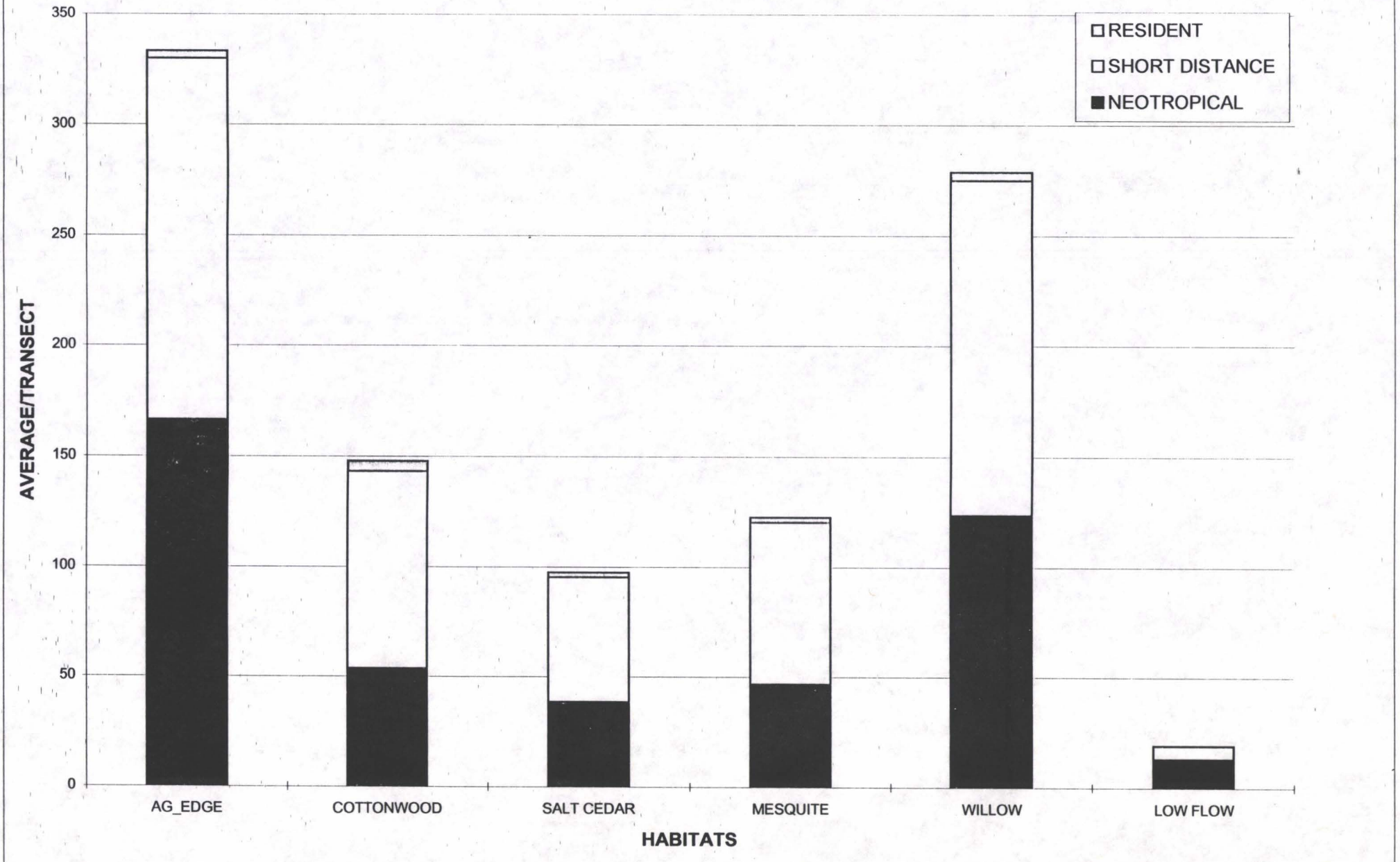


FIGURE 9a SPATIAL DISTRIBUTION ALONG LFCC OF MIGRATING SONGBIRDS SPRING 1996-1998

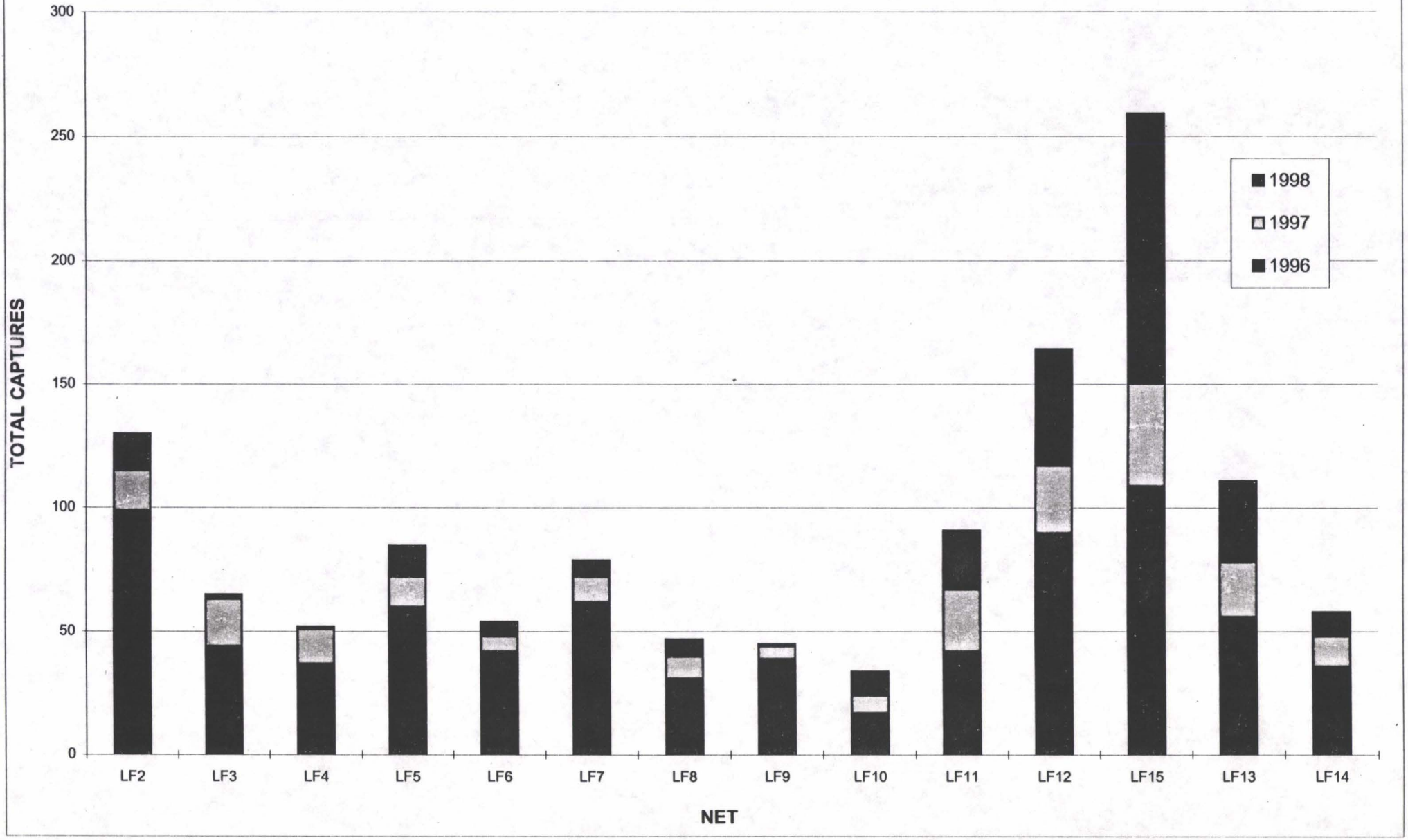


FIGURE 9b SPATIAL DISTRIBUTION ALONG LFCC OF MIGRATING SONGBIRDS FALL 1996-1998

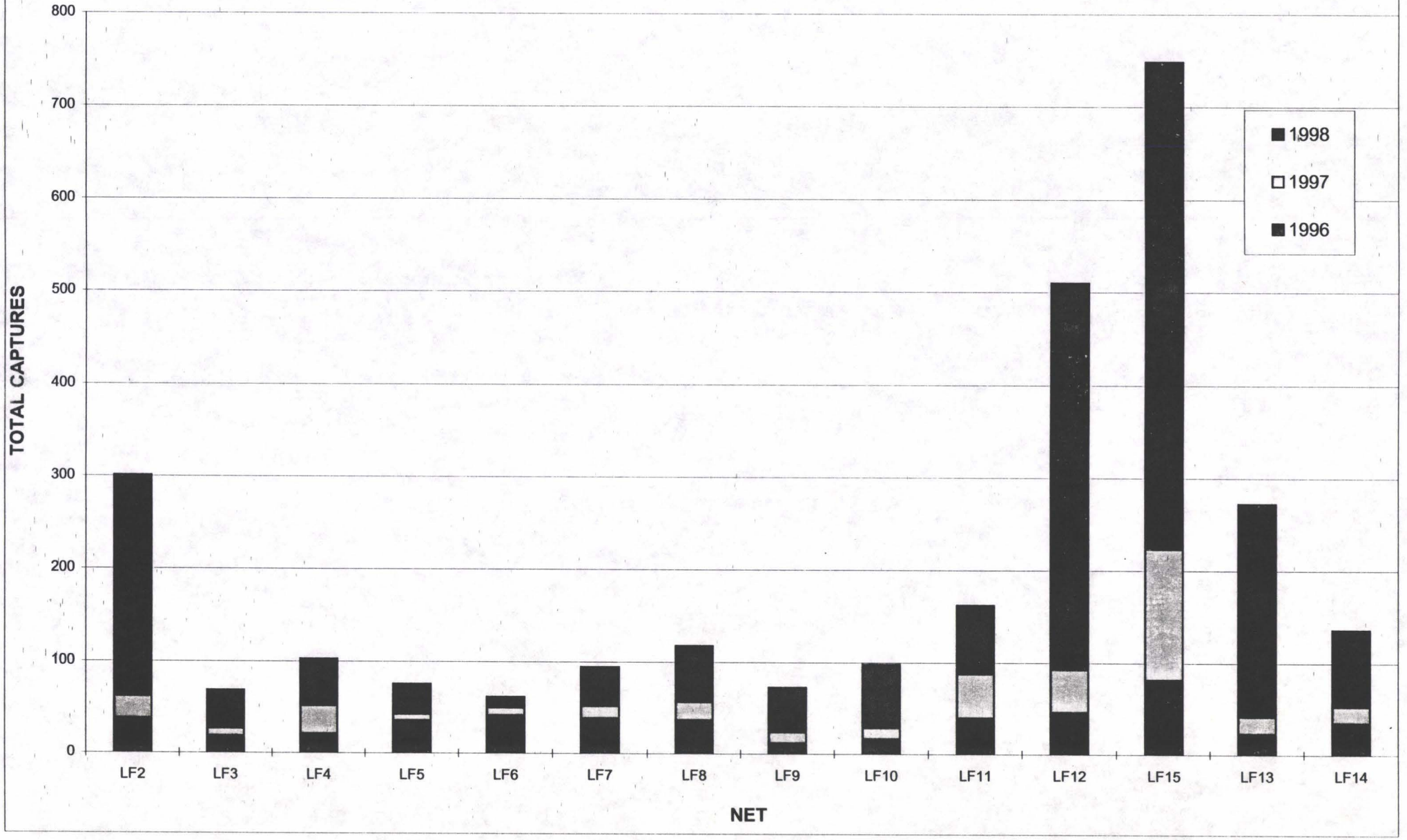


FIGURE 9c SPATIAL DISTRIBUTION OF MIGRATING WARBLERS ALONG LOW FLOW CONVEYANCE CHANNEL SPRING 1996-1998

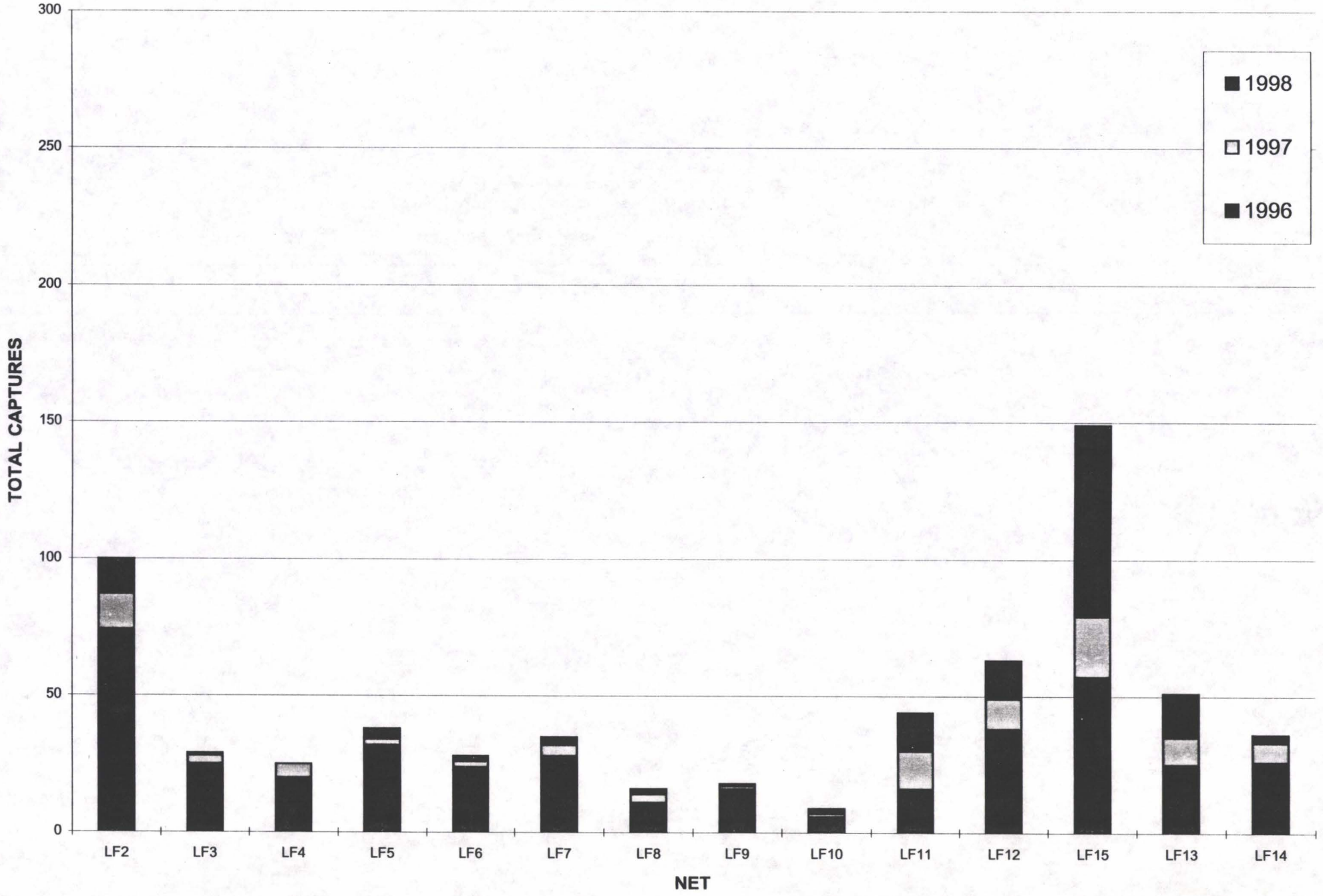


FIGURE 9d SPATIAL DISTRIBUTION OF MIGRATING WARBLERS ALONG LOW FLOW CONVEYANCE CHANNEL FALL 1996-1998

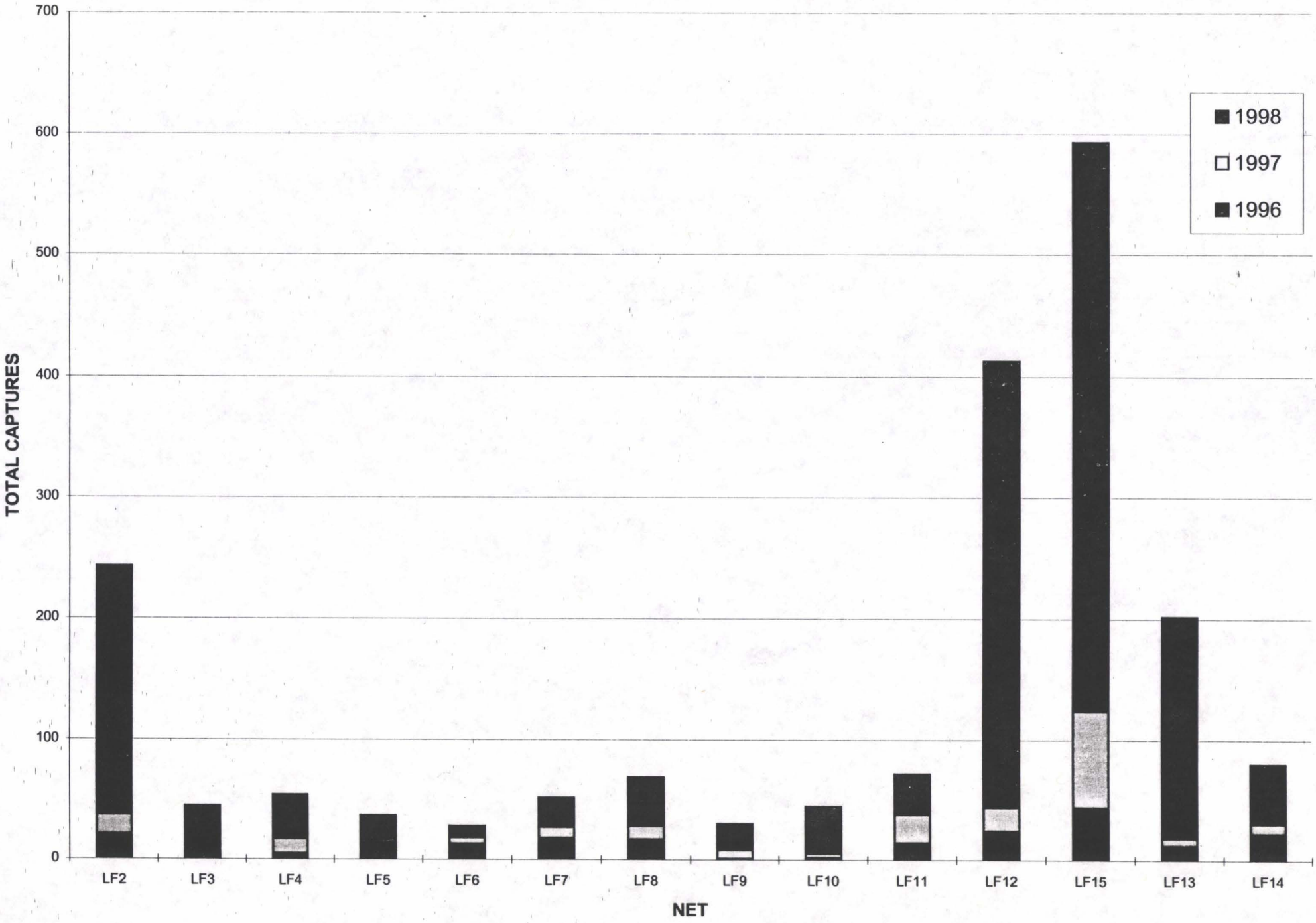


FIGURE 9e SPATIAL DISTRIBUTION OF MIGRATING WILLOW FLYCATCHER ALONG LOW FLOW CONVEYANCE CHANNEL SPRING 1996-1998

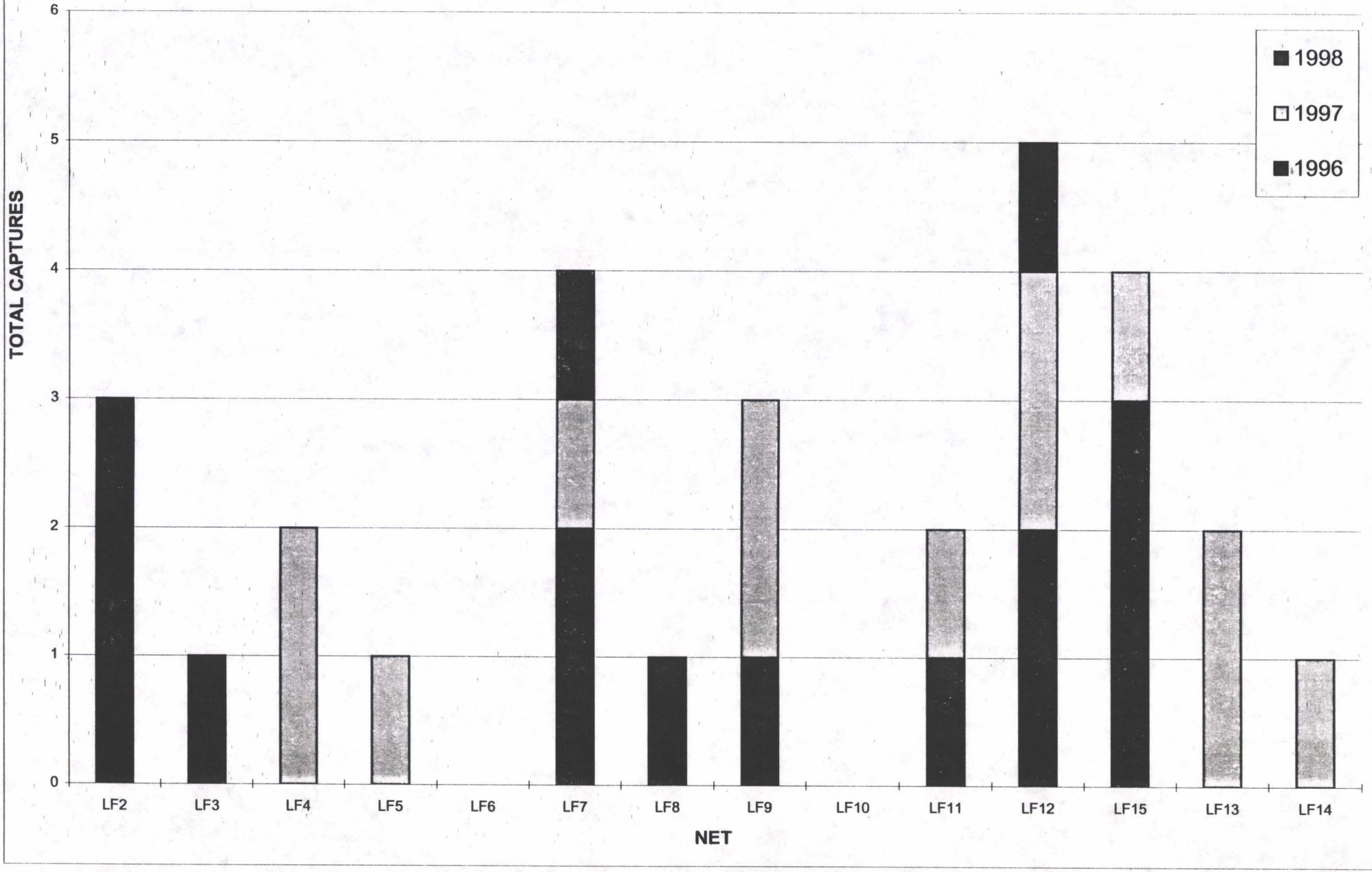


FIGURE 9f SPATIAL DISTRIBUTION OF MIGRATING WILLOW FLYCATCHER ALONG LOW FLOW CONVEYANCE CHANNEL FALL 1996-1998

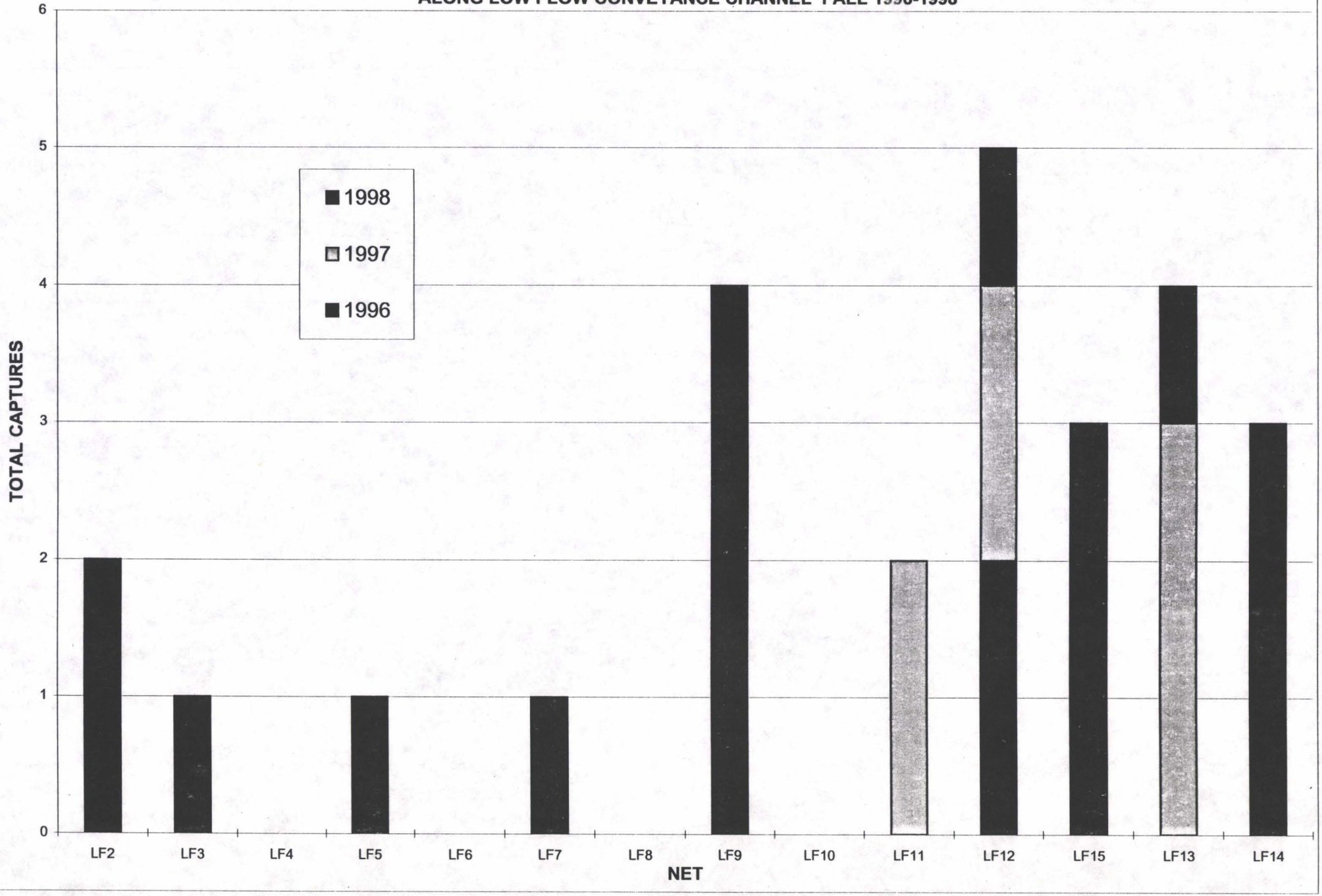


FIGURE 10 BIRD CAPTURES BY HABITAT AND EFFORT COMPARED TO LARGER AREAS OF RIO GRANDE REACHES

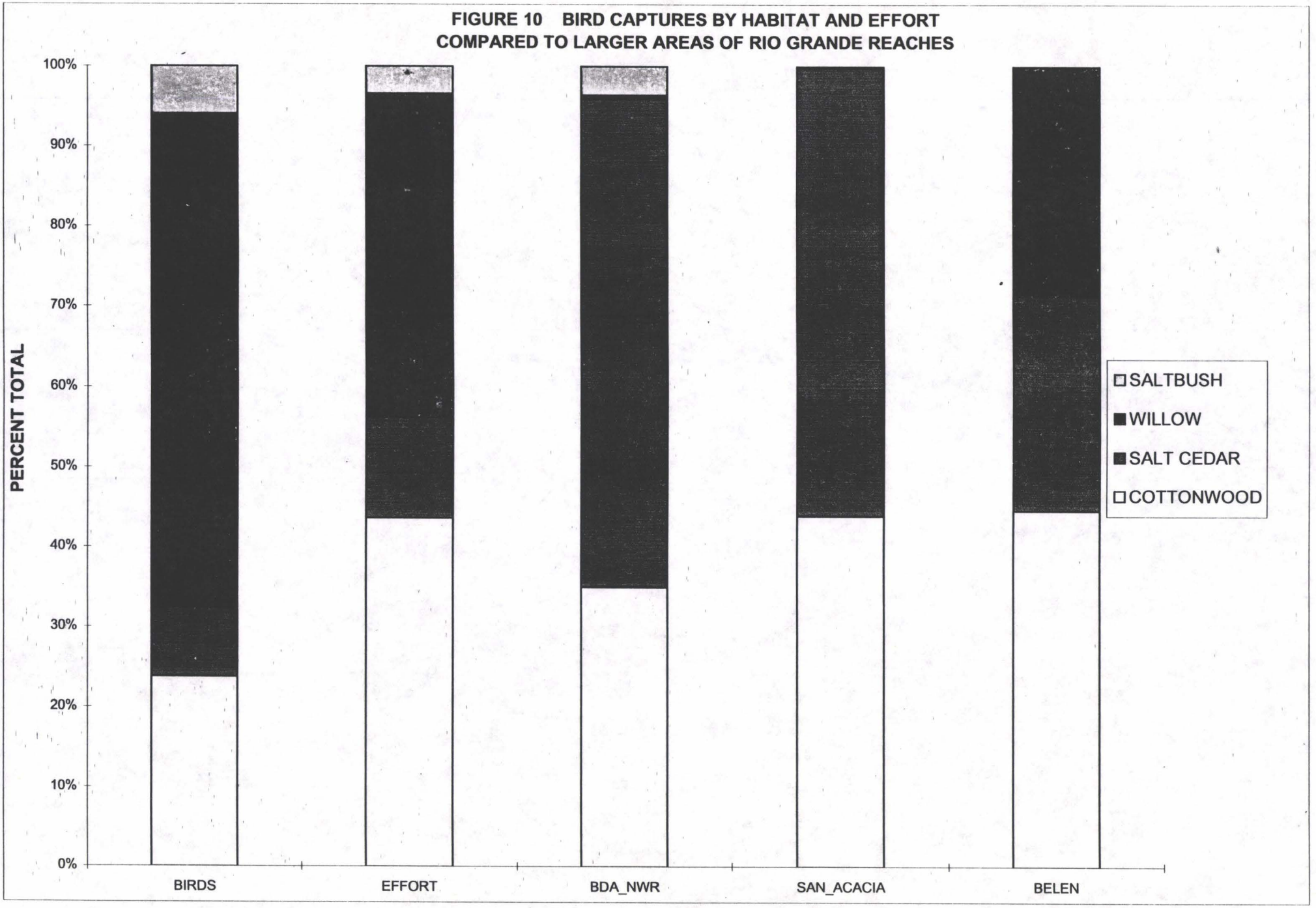


Figure 11. Spring and fall arthropod numbers per trap day using glueboard sampling for classes of willow at Bosque del Apache, NWR, 1996 and 1997.

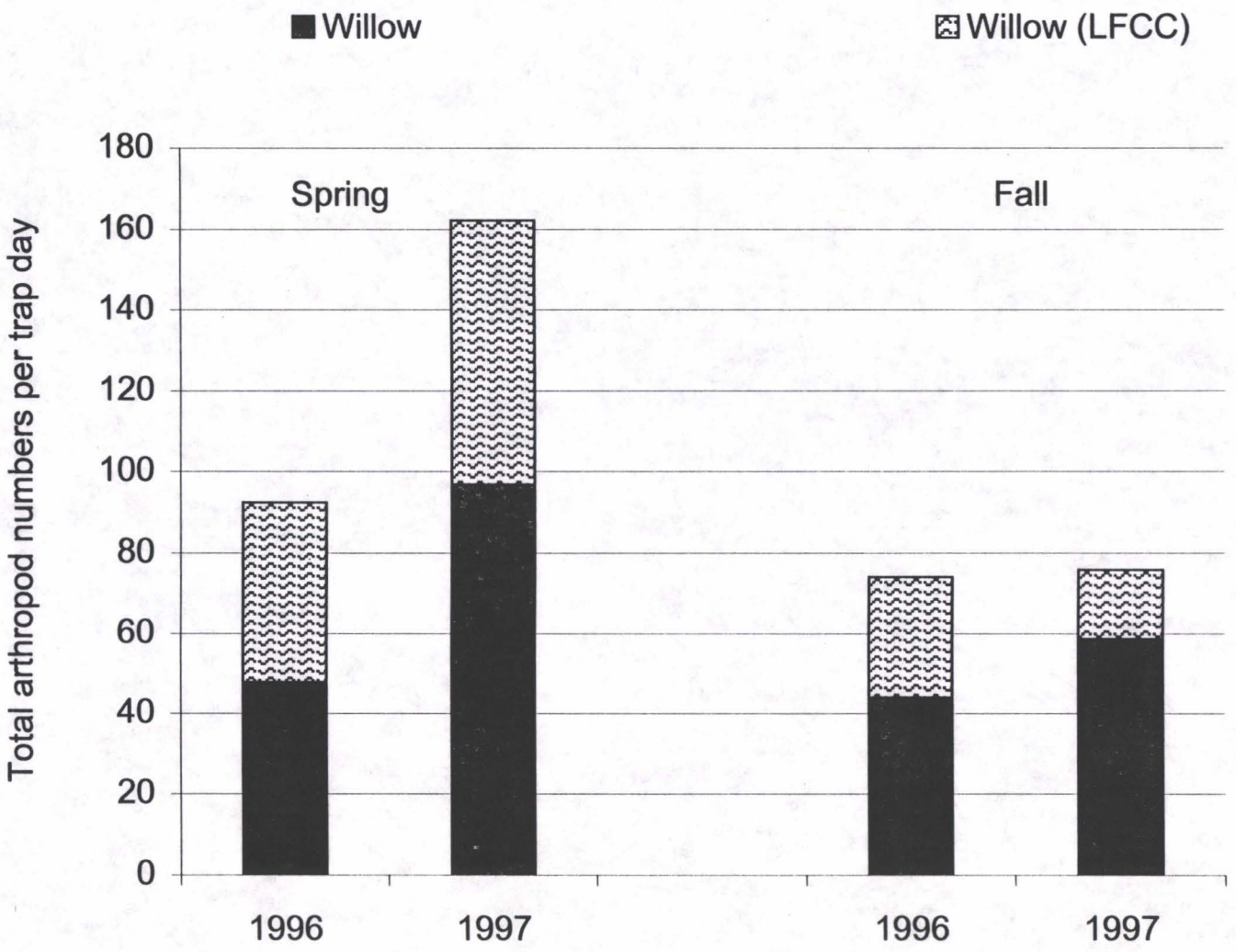


Figure 12. Spring arthropod numbers per trap day using pitfall sampling for five vegetation classes at Bosque del Apache, NWR, 1996 to 1998. Totals calculated without ants (Formicidae). Willows were not sampled in 1998.

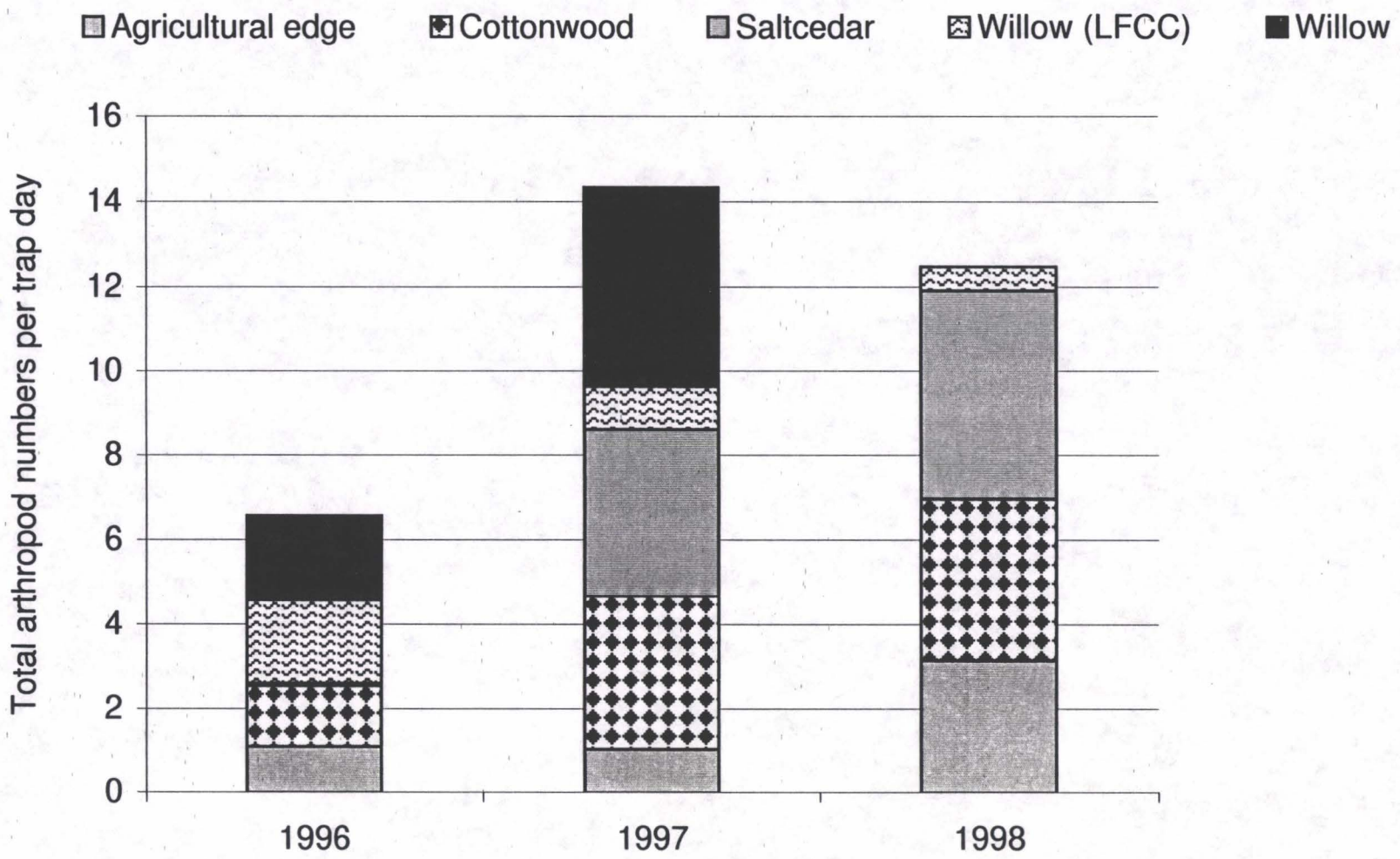


Figure 13. Fall arthropod numbers per trap day using pitfall sampling for five vegetation classes at Bosque del Apache, NWR, Fall, 1996 to 1998. Totals calculated without ants (Formicidae). Willows were not sampled in 1998.

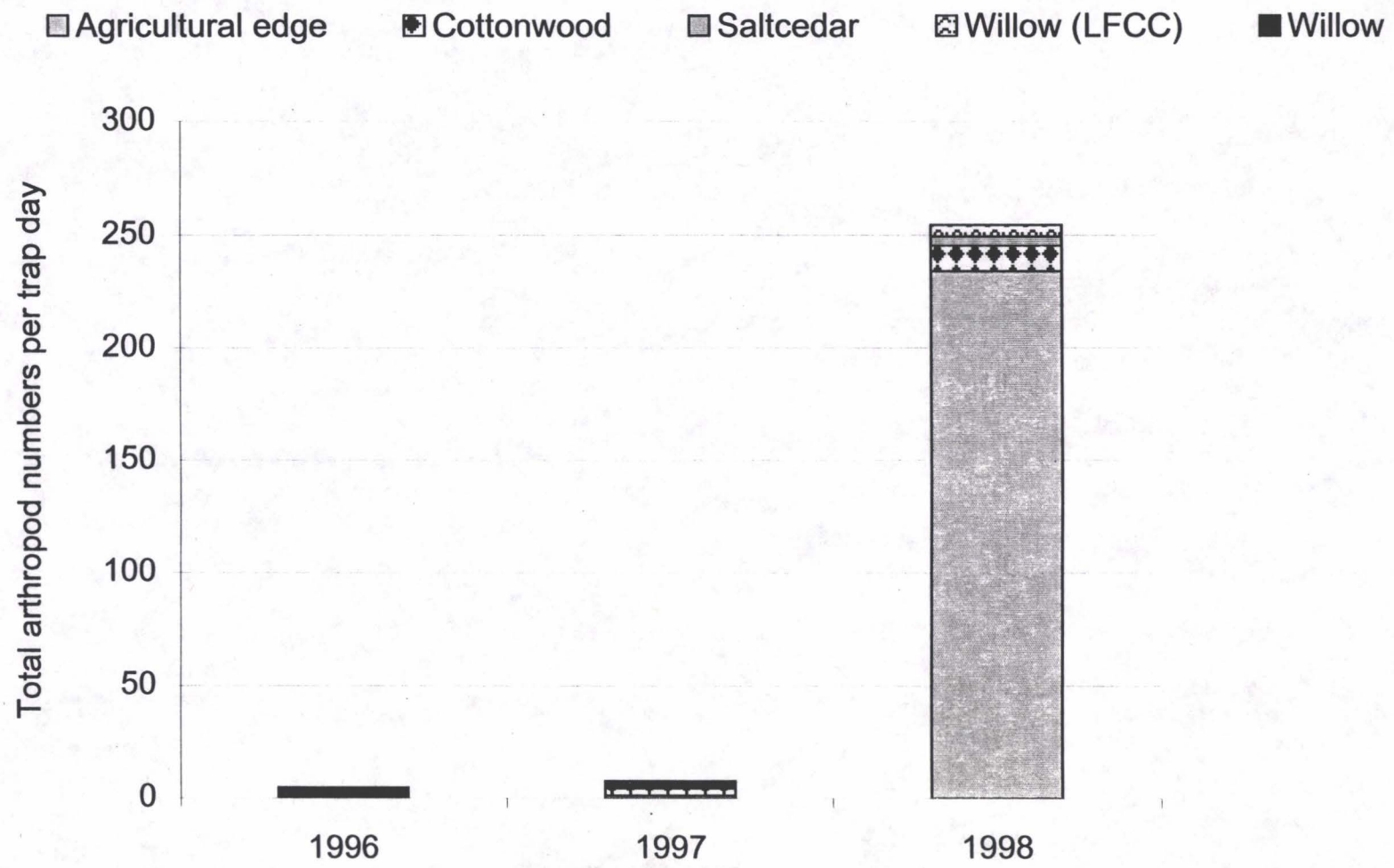


Figure 14. Spring arthropod numbers per trap day using glueboard sampling for five vegetation classes at Bosque del Apache, NWR, 1996 to 1998. Willows were not sampled in 1998.

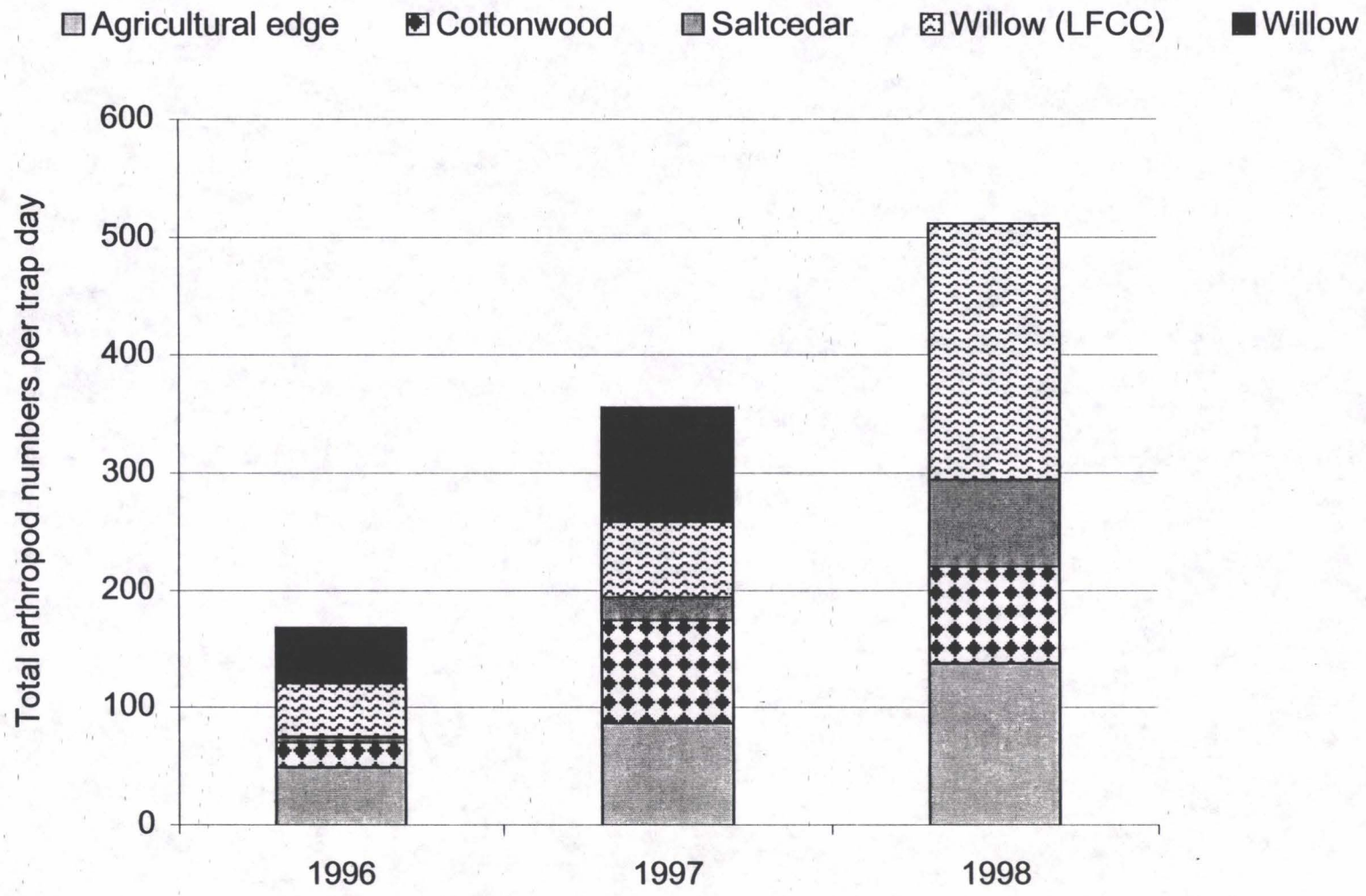


Figure 15. Fall arthropod numbers per trap day using glueboard sampling for five vegetation classes at Bosque del Apache, NWR, 1996 to 1998. Willows were not sampled in 1998.

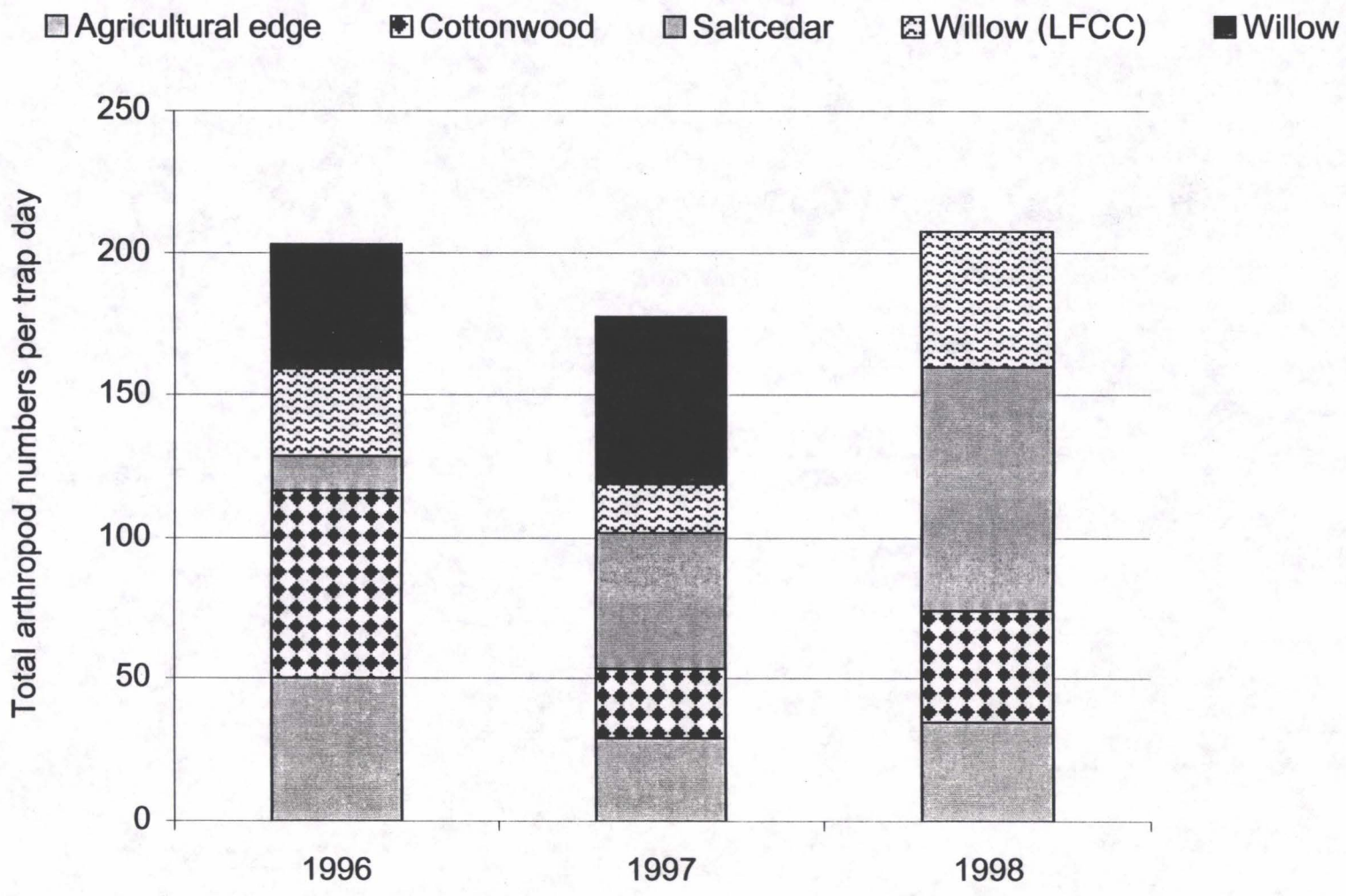


Figure 16. Spring and fall arthropod numbers per trap day using shrub-sweep sampling in five vegetation classes at Bosque del Apache, NWR, 1997 to 1998. Willows were not sampled in 1998.

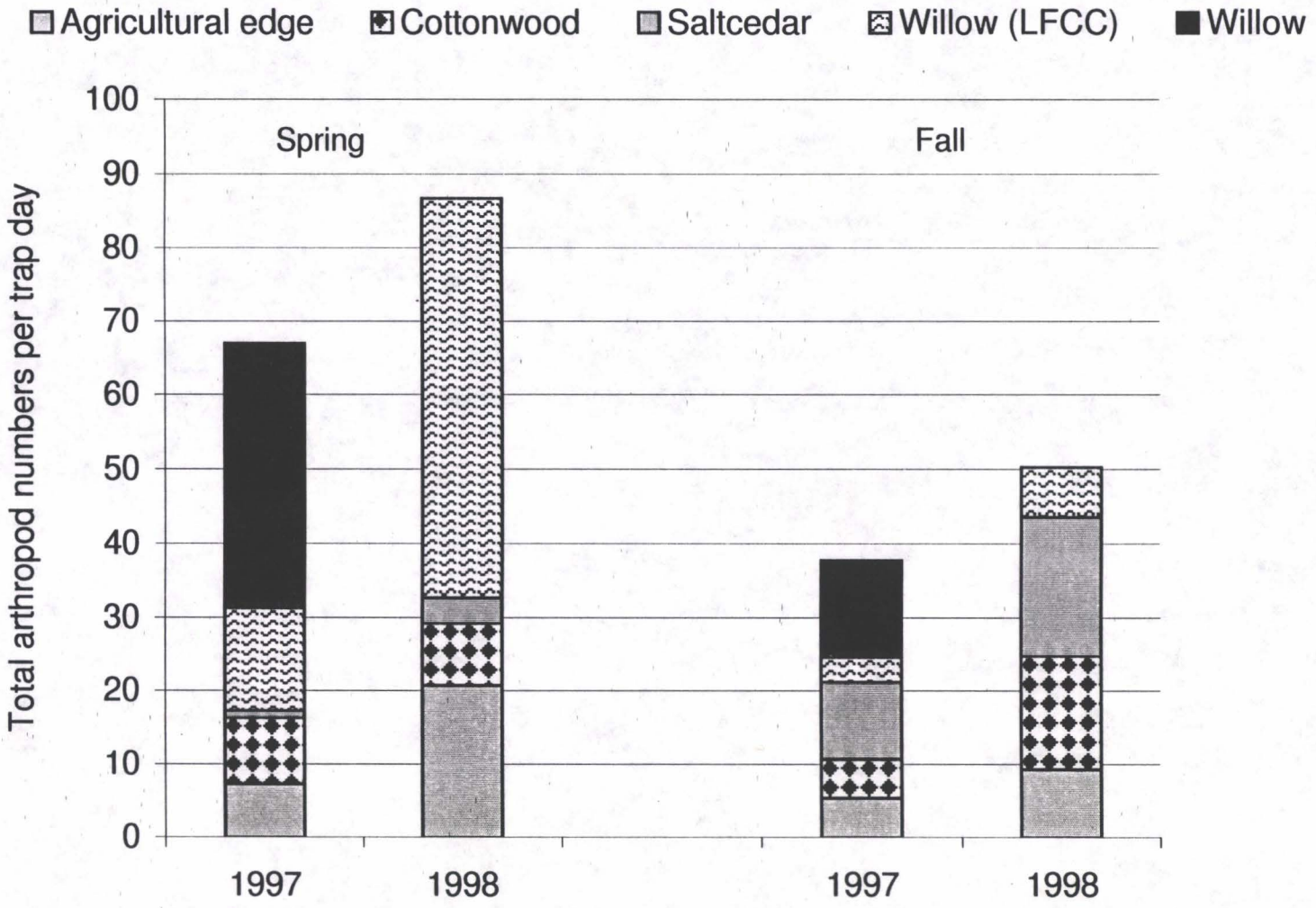


Figure 17. Spring and fall arthropod numbers per trap day using mistnet-sampling in five vegetation classes at Bosque del Apache, NWR,1997 to 1998. Omitting bee swarm, 1998 cottonwoods.

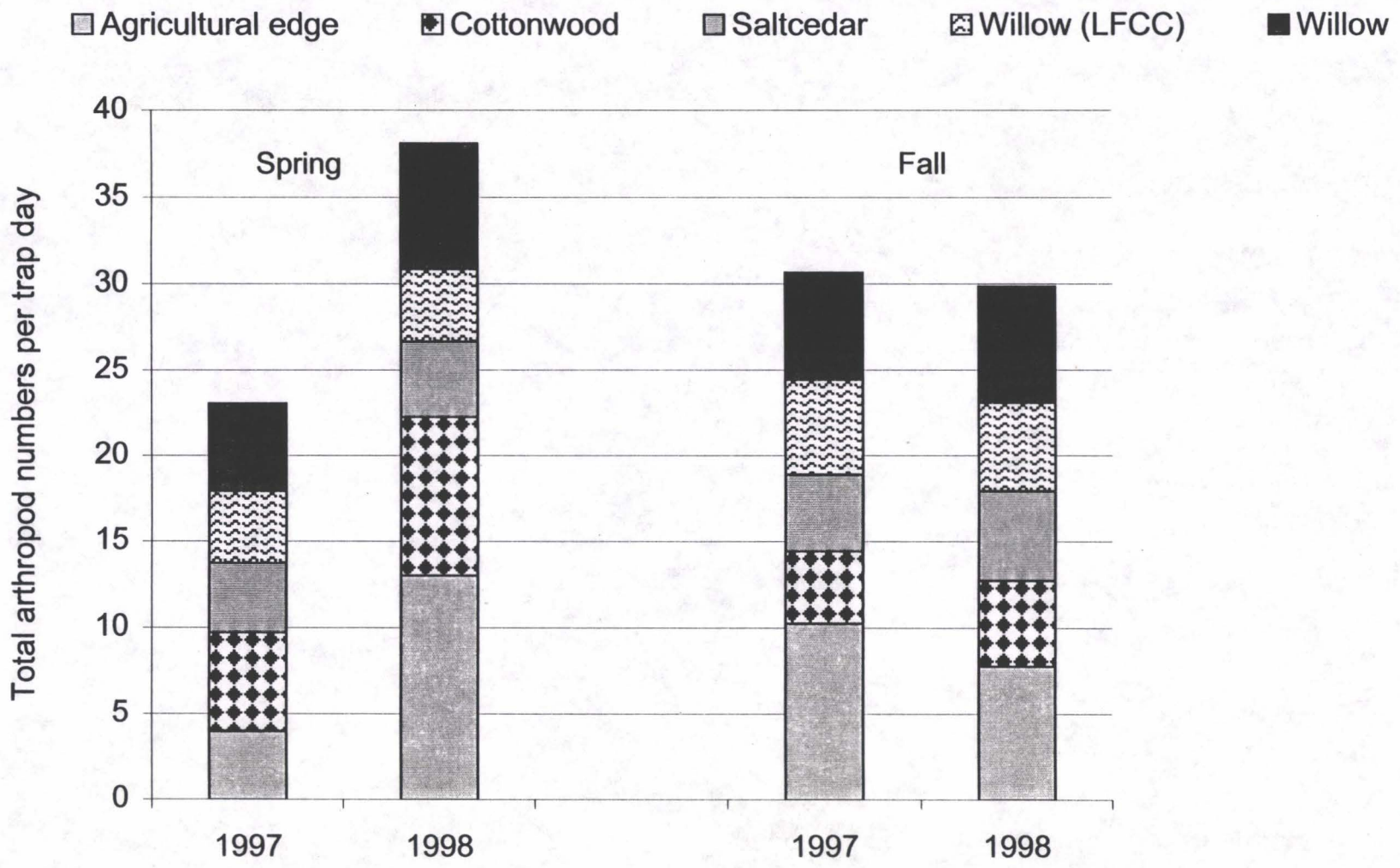


Figure 18. Numbers of Diptera (flies) per trap day captured on glueboards in spring and fall, 1996 to 1998.

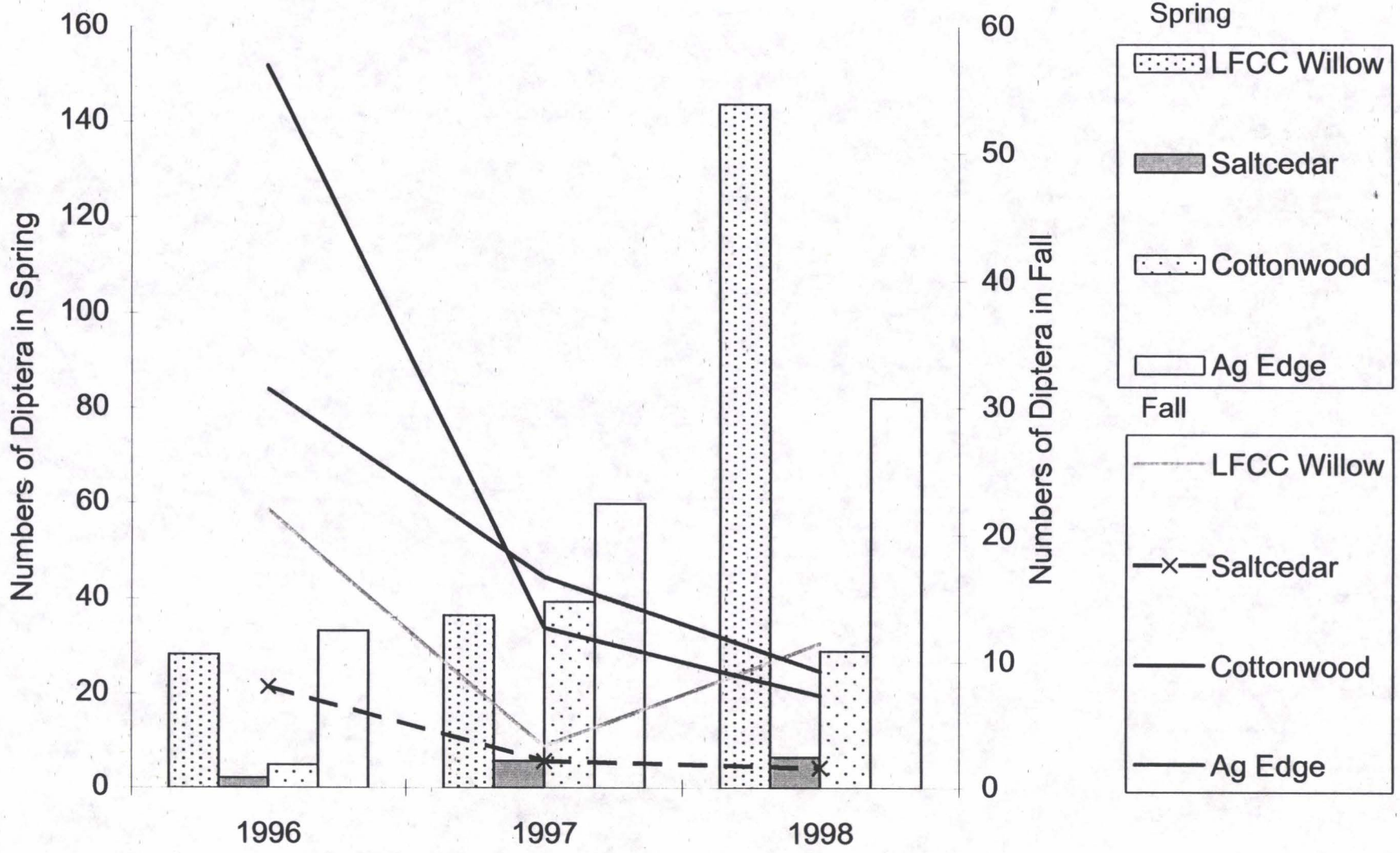


Figure 19. Numbers of Hymenoptera (bees and wasps) per trap day captured on glueboards in spring and fall, 1996 to 1998.

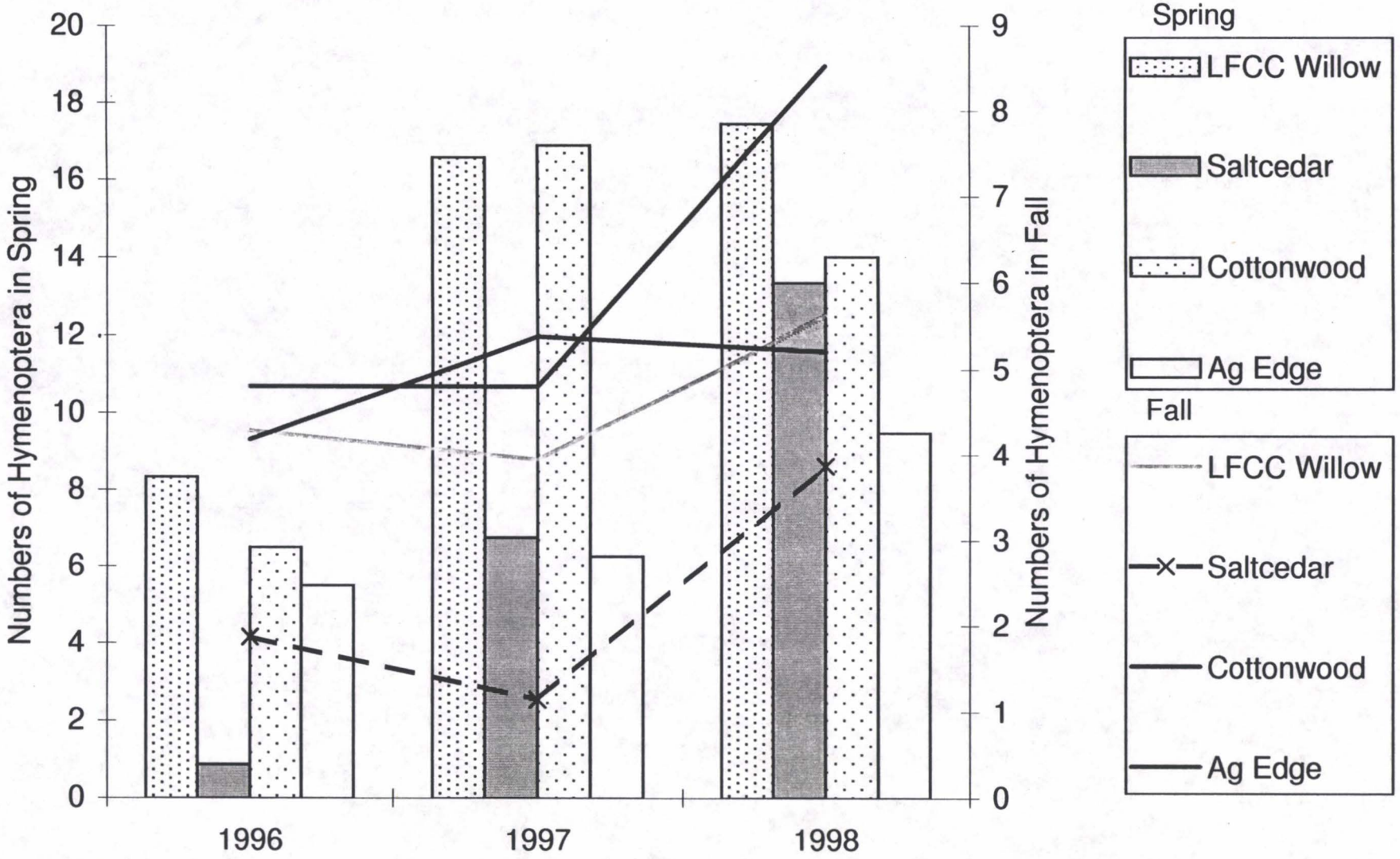


Figure 20. Numbers of Hemiptera (true bugs) per trap day captured on glueboards in spring and fall, 1996 to 1998.

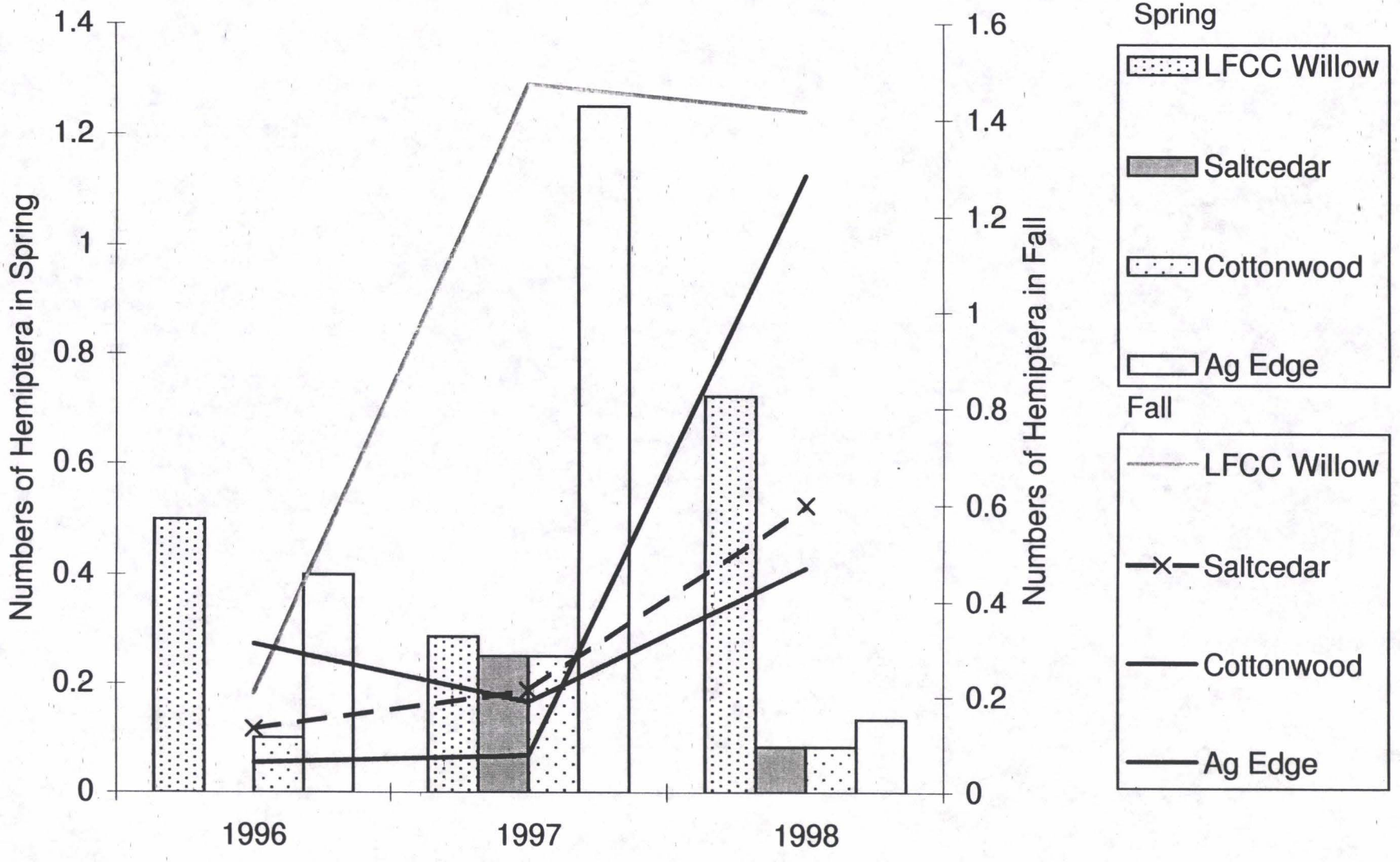


Table 1. Number of captures for 132 species of birds mist-netted at the Bosque del Apache during 1994 through 1998.

	1994			1995			1996			1997			1998			
Common Name	Spring	Fall	Total	Spring	Fall	Total	Spring	Fall	Total	Spring	Fall	Total	Spring	Fall	Total	Grand Total
HAWKS																
American Kestrel	1	0	1	0	0	0	0	0	0	0	0	0	0	1	1	2
Prairie Falcon	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1
Northern Harrier	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1
Sharp-shinned Hawk	1	0	1	0	0	0	0	0	0	1	0	1	1	0	1	3
Coopers Hawk	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1
DOVES																
Mourning Dove	0	0	0	0	0	0	0	0	0	1	3	4	4	0	4	8
White-winged Dove	0	0	0	0	0	0	0	0	0	1	0	1	2	0	2	3
Common Ground Dove	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1
CUCKOOS																
Greater Roadrunner	0	0	0	0	0	0	0	1	1	2	1	3	0	0	0	4
Yellow-billed Cuckoo	4	2	6	1	2	3	2	2	4	0	3	3	1	0	1	17
HUMMINGBIRDS*																
Black-chinned Hummingbird	0	10	10	NA	NA	NA	42	51	93	67	27	94	62	18	80	277
Calliope Hummingbird	0	0	0	NA	NA	NA	0	2	2	0	1	1	0	0	0	4
Broad-tailed Hummingbird	0	1	1	NA	NA	NA	5	4	9	2	0	2	1	6	7	19
Rufous Hummingbird	0	4	4	NA	NA	NA	0	13	13	0	3	3	0	0	5	25

Table 1. Cont.

Common Name	1994 Spring	1994 Fall	1994 Total	1995 Spring	1995 Fall	1995 Total	1996 Spring	1996 Fall	1996 Total	1997 Spring	1997 Fall	1997 Total	1998 Spring	1998 Fall	1998 Total	Grand Total
KINGFISHERS																
Belted Kingfisher	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	2
WOODPECKERS																
Hairy Woodpecker	1	3	4	0	2	2	1	0	1	1	0	1	1	0	1	9
Downy woodpecker	1	4	5	0	2	2	0	0	0	0	2	2	0	2	2	11
Ladder-backed Woodpecker	0	1	1	2	1	3	0	0	0	1	0	1	0	1	1	6
Red-naped Sapsucker	0	1	1	0	3	3	0	2	2	0	1	1	0	2	2	9
Williamson's Sapsucker	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1
Northern Flicker	2	5	7	0	2	2	0	4	4	0	2	2	0	0	0	15
FLYCATCHERS																
Western Kingbird	0	0	0	1	0	1	1	0	1	1	1	2	0	2	2	6
Brown-crested Flycatcher	3	1	4	0	0	0	0	1	1	0	0	0	0	0	0	5
Ash-throated Flycatcher	5	0	5	5	0	5	13	0	13	12	0	12	6	0	6	41
Say's Pheobe	0	0	0	0	0	0	1	1	2	0	0	0	0	0	0	2
Black Pheobe	5	0	5	9	1	10	8	1	9	9	2	11	4	1	5	40
Western Wood-pewee	19	9	28	17	8	25	20	20	40	7	3	10	10	2	12	115
Western Flycatcher	0	3	3	1	8	9	5	10	15	1	4	5	5	4	9	41
Willow Flycatcher	2	5	7	18	6	24	27	23	50	29	13	42	7	22	29	152

Table 1. Cont.

Common Name	1994			1995			1996			1997			1998			Grand Total
	Spring	Fall	Total	Spring	Fall	Total	Spring	Fall	Total	Spring	Fall	Total	Spring	Fall	Total	
Acadian Flycatcher	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1
Hammond's Flycatcher	0	2	2	0	2	2	9	5	14	0	0	0	3	1	4	22
Dusky Flycatcher	33	8	41	42	4	46	102	21	123	31	7	38	58	18	76	324
Gray Flaycatcher	5	8	13	4	11	15	10	2	12	1	2	3	6	1	7	50
Olive-sided Flycatcher	0	0	0	6	0	6	0	0	0	0	0	0	2	0	2	8
VIREOS																
Red-eyed Vireo	0	1	1	0	0	0	1	1	0	0	0	0	0	0	0	2
Warbling Vireo	1	12	13	11	6	17	45	46	91	12	18	30	37	25	62	213
Yellow-throated Vireo	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1
Solitary Vireo	1	3	4	4	8	12	13	5	18	2	1	3	1	4	5	42
Gray Vireo	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1
White-eyed Vireo	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1
JAYS																
Western Scrub Jay	0	6	6	0	5	5	0	1	1	0	1	1	0	0	0	13
SWALLOWS																
Barn Swallow	0	1	1	0	0	0	7	5	12	4	2	6	9	6	15	34
Northern Rough-winged Swallow	9	0	9	7	0	7	3	0	3	6	0	6	8	1	9	34

Table 1. Cont.

Common Name	1994 Spring	1994 Fall	1994 Total	1995 Spring	1995 Fall	1995 Total	1996 Spring	1996 Fall	1996 Total	1997 Spring	1997 Fall	1997 Total	1998 Spring	1998 Fall	1998 Total	Grand Total
Violet-green Swallow	1	0	1	0	0	0	0	0	0	0	0	0	1	0	1	2
CHICKADEES																
Mountain Chickadee	0	1	1	0	5	5	1	1	2	0	0	0	0	0	0	8
VERDINS																
Verdin	0	1	1	0	3	3	0	2	2	0	0	0	1	2	3	9
BUSHTITS																
Common Bushtit	0	0	0	0	0	0	0	1	1	0	19	19	0	0	0	20
NUTHATCHES																
White-breasted Nuthatch	2	4	6	2	3	5	1	0	1	0	0	0	0	2	2	14
Red-breasted Nuthatch	0	1	1	0	2	2	0	3	3	0	0	0	0	0	0	6
CREEPERS																
Brown Creeper	0	0	0	0	2	2	0	11	11	0	0	0	0	2	2	15
WRENS																
Cactus Wren	0	0	0	0	1	1	0	0	0	0	1	1	0	0	0	2
Rock Wren	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1
Carolina Wren	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1
Bewick's Wren	10	11	21	7	23	30	15	25	40	13	22	35	11	22	33	159

Table 1. Cont.

Common Name	1994 Spring	1994 Fall	1994 Total	1995 Spring	1995 Fall	1995 Total	1996 Spring	1996 Fall	1996 Total	1997 Spring	1997 Fall	1997 Total	1998 Spring	1998 Fall	1998 Total	Grand Total
House Wren	0	3	3	6	7	13	33	11	44	7	2	9	3	10	13	82
Winter Wren	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1
Marsh Wren	0	1	1	0	2	2	1	3	4	0	0	0	0	3	3	10
GNATCATCHERS																
Blue-gray gnatcatcher	1	0	1	0	0	0	3	0	3	0	2	2	1	0	1	7
THRUSHES																
Townsend's Solitaire	0	0	0	0	1	1	1	1	2	1	0	1	0	0	0	4
Swainson's Thrush	0	2	2	3	0	3	3	2	5	1	0	1	2	0	2	13
Hermit Thrush	2	4	6	7	20	27	15	9	24	3	1	4	1	11	12	73
American Robin	13	0	13	6	0	6	13	9	22	11	0	11	1	4	5	57
Golden crowned Kinglet	0	0	0	2	1	3	0	0	0	0	0	0	0	0	0	3
Ruby-crowned Kinglet	6	135	141	25	104	129	25	134	159	30	115	145	14	110	124	698
MIMIC THRUSHES																
Brown Thrasher	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1
Chrissal Thrasher	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1
Northern Mockingbird	1	0	1	0	0	0	6	0	6	1	0	1	0	1	1	9
Gray Catbird	0	1	1	3	3	6	2	3	5	0	0	0	0	4	4	16

Table 1. Cont.

Common Name	1994			1995			1996			1997			1998			Grand Total
	Spring	Fall	Total	Spring	Fall	Total	Spring	Fall	Total	Spring	Fall	Total	Spring	Fall	Total	
WOOD WARBLERS																
Black and White Warbler	0	0	0	0	0	0	1	2	3	0	0	0	0	0	0	3
Prothonotary Warbler	0	0	0	0	0	0	0	2	2	0	1	1	0	0	0	3
Blue-winged Warbler	0	0	0	0	0	0	1	0	1	1	0	1	0	0	0	2
Golden-winged Warbler	0	0	0	0	0	0	0	0	0	2	0	2	0	0	0	2
Lucy's warbler	4	0	4	1	0	1	1	0	1	2	0	2	2	0	2	10
Virginia's Warbler	7	12	19	5	12	17	18	34	52	5	12	17	9	45	54	159
Nashville Warbler	0	0	0	1	0	1	3	0	3	0	1	1	0	0	0	5
Orange-crowned Warbler	3	20	23	10	37	47	32	37	69	10	30	40	9	211	220	399
Yellow Warbler	10	20	30	29	34	63	44	77	121	48	34	82	41	236	277	532
Black-throated Blue Warbler	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1
Yellow-rumped Warbler	5	42	47	21	25	46	53	39	92	9	7	16	27	47	74	275
Magnolia Warbler	0	0	0	0	0	0	2	0	2	0	0	0	0	0	0	2
Chestnut-sided Warbler	0	0	0	0	0	0	2	0	2	0	0	0	0	0	0	2
Bay-breasted Warbler	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1
Black-throated Gray Warbler	0	0	0	1	0	1	1	0	1	0	1	1	0	1	1	4
Townsend's Warbler	0	1	1	1	3	4	2	1	3	0	2	2	1	8	9	19

Table 1. Cont.

Common Name	1994 Spring	1994 Fall	1994 Total	1995 Spring	1995 Fall	1995 Total	1996 Spring	1996 Fall	1996 Total	1997 Spring	1997 Fall	1997 Total	1998 Spring	1998 Fall	1998 Total	Grand Total
Northern Parula	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1
Prairie Warbler	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1
Ovenbird	0	0	0	5	0	5	4	0	4	0	0	0	0	0	0	9
Northern Waterthrush	0	1	1	0	1	1	0	8	8	0	4	4	1	2	3	17
Kentucky Warbler	1	0	1	0	0	0	1	0	1	0	0	0	0	0	0	2
MacGillivray's Warbler	34	40	74	51	42	93	234	62	296	30	41	71	22	84	106	640
Common Yellowthroat	21	14	35	34	28	62	63	19	82	45	21	66	24	37	61	282
Yellow-breasted Chat	5	2	7	7	4	11	26	4	30	10	8	18	8	7	15	81
Hooded Warbler	0	0	0	0	0	0	2	0	2	0	0	0	0	0	0	2
Wilson's Warbler	23	404	427	176	241	417	348	380	728	124	294	418	91	1347	1438	3428
Canada Warbler	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1
American Redstart	0	0	0	0	1	1	1	1	2	1	1	2	0	1	1	6
TANAGERS																
Western Tanager	1	11	12	3	2	5	4	31	35	2	3	5	1	10	11	68
Hepatic Tanager	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	2
Summer Tanager	10	12	22	7	15	22	13	37	50	6	10	16	7	14	21	131
SPARROWS																
Vesper Sparrow	2	5	7	0	0	0	2	1	3	1	2	3	0	6	6	19
Savannah Sparrow	0	32	32	0	20	20	0	4	4	1	8	9	0	7	7	72

Table 1. Cont.

Common Name	1994			1995			1996			1997			1998			Grand Total
	Spring	Fall	Total	Spring	Fall	Total	Spring	Fall	Total	Spring	Fall	Total	Spring	Fall	Total	
Lark Sparrow	1	46	47	0	10	10	4	7	11	0	8	8	1	14	15	91
Harris' Sparrow	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1
Golden-crowned Sparrow	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1
White-crowned Sparrow	73	220	293	27	287	314	77	386	463	132	71	203	15	247	262	1535
White-throated Sparrow	1	0	1	1	3	4	0	3	3	0	0	0	0	0	0	8
Chipping Sparrow	12	59	71	0	57	57	33	265	298	9	17	26	2	115	117	569
Clay-colored Sparrow	0	27	27	0	13	13	0	0	0	0	11	11	0	65	65	116
Brewer's Sparrow	1	52	53	0	31	31	57	40	95	6	33	39	0	81	81	299
Dark-eyed Junco	5	93	98	10	103	113	41	140	181	9	29	38	5	72	77	507
Black-throated Sparrow	0	0	0	0	2	2	1	0	1	0	1	1	0	3	3	7
Sage Sparrow	0	0	0	0	1	1	0	0	0	0	2	2	0	1	1	4
Song Sparrow	0	62	62	4	66	70	3	119	122	2	28	30	0	72	72	356
Lincoln's Sparrow	0	20	20	1	16	17	14	126	140	4	34	38	2	49	51	266
Swamp Sparrow	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1
Fox Sparrow	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1
Spotted Towhee	20	13	33	16	36	52	22	50	72	10	19	29	12	19	31	217
Green-tailed Towhee	2	9	11	1	1	2	18	15	33	6	8	14	6	8	14	74
Canyon Towhee	0	1	1	0	0	0	1	0	1	0	1	1	0	7	7	10

Table 1. Cont.

Common Name	1994 Spring	1994 Fall	1994 Total	1995 Spring	1995 Fall	1995 Total	1996 Spring	1996 Fall	1996 Total	1997 Spring	1997 Fall	1997 Total	1998 Spring	1998 Fall	1998 Total	Grand Total
GROSBEAKS & BUNTINGS																
Pyrrhuloxia	0	2	2	0	0	0	0	2	2	0	0	0	0	0	0	4
Black-headed Grosbeak	30	7	37	32	41	73	31	25	56	25	3	28	24	11	35	229
Rose-breasted Grosbeak	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1
Lark Bunting	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	2
Blue Grosbeak	28	26	54	24	32	56	25	61	86	14	76	90	5	58	63	349
Indigo Bunting	0	1	1	1	1	2	7	4	11	8	7	15	0	1	1	30
Lazuli Bunting	0	6	6	0	6	6	5	31	36	2	11	13	1	16	17	78
Painted Bunting	0	0	0	0	1	1	0	2	2	0	0	0	1	1	2	5
BLACKBIRDS																
Brown-headed Cowbird	7	1	8	6	1	7	8	0	8	21	0	21	9	0	9	53
Red-winged Blackbird	0	0	0	0	2	2	1	2	3	2	0	2	4	0	4	11
Yellow-headed Blackbird	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1
Northern Oriole	3	5	8	2	2	4	5	3	8	3	0	3	1	5	6	29
Common Grackle	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1
Great-tailed Grackle	0	0	0	0	0	0	0	0	0	3	0	3	0	0	0	3
FINCHES																
House Finch	2	0	2	2	1	3	15	1	16	7	1	8	4	2	6	35

Table 1. Cont.

	1994			1995			1996			1997			1998			
Common Name	Spring	Fall	Total	Spring	Fall	Total	Spring	Fall	Total	Spring	Fall	Total	Spring	Fall	Total	Grand Total
American Goldfich	0	0	0	0	3	3	2	1	3	1	0	1	0	0	0	7
Pine Siskin	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
Lesser Goldfinch	0	0	0	3	4	7	6	12	18	0	2	2	1	3	4	31

* Note that hummingbirds were not banded, So some of the captured birds may be repeats.

Table 2. Number of captures for 82 species of birds mist-netted at the Low Flow Conveyance Channel Bosque del Apache during 1996 through 1998.

	1996			1997			1998			
Common Name	Spring	Fall	Total	Spring	Fall	Total	Spring	Fall	Total	Grand Total
HAWKS										
Sharp-shinned Hawk	0	0	0	0	0	0	1	0	1	1
DOVES										
Mourning Dove	0	0	0	0	3	3	0	0	0	3
Common Ground Dove	0	0	0	1	0	1	0	0	0	1
CUCKOOS										
Greater Roadrunner	0	1	1	1	1	2	0	0	0	3
KINGFISHERS										
Belted Kingfisher	0	0	0	0	2	2	0	0	0	2
FLYCATCHERS										
Ash-throated Flycatcher	4	0	4	1	0	1	3	0	3	8
Say's Pheobe	1	0	1	0	0	0	0	0	0	1
Black Pheobe	5	0	5	1	1	2	4	1	5	12
Western Wood-pewee	8	1	9	2	0	2	3	0	3	14
Western Flycatcher	2	1	3	0	1	1	1	3	4	8
Willow Flycatcher	13	8	21	13	7	20	2	11	13	54

Table 2. Cont.

Common Name	1996 Spring	1996 Fall	1996 Total	1997 Spring	1997 Fall	1997 Total	1998 Spring	1998 Fall	1998 Total	Grand Total
Acadian Flycatcher	0	0	0	0	0	0	1	0	1	1
Hammond's Flycatcher	0	1	1	0	0	0	1	0	1	2
Dusky Flycatcher	48	4	52	5	2	7	21	9	30	89
Gray Flaycatcher	5	0	5	0	1	1	1	0	1	7
VIREOS										
Red-eyed Vireo	1	0	1	0	0	0	0	0	0	1
Warbling Vireo	30	15	45	9	11	20	29	23	52	117
Solitary Vireo	5	0	5	0	0	0	1	2	3	8
SWALLOWS										
Barn Swallow	7	5	12	4	2	6	9	5	14	32
Northern Rough-winged Swallow	0	0	0	1	0	1	4	1	5	6
CHICKADEES										
Mountain Chickadee	1	0	1	0	0	0	0	0	0	1
BUSHTITS										
Common Bushtit	0	0	0	0	15	15	0	0	0	15

Table 2. Cont.

Common Name	1996 Spring	1996 Fall	1996 Total	1997 Spring	1997 Fall	1997 Total	1998 Spring	1998 Fall	1998 Total	Grand Total
WRENS										
Rock Wren	0	1	1	0	0	0	0	0	0	1
Bewick's Wren	3	5	8	2	3	5	3	3	6	19
House Wren	7	4	11	2	0	2	1	4	5	18
Marsh Wren	1	1	2	0	0	0	0	1	1	3
THRUSHES										
Townsend's Solitaire	0	0	0	1	0	1	0	0	0	1
Swainson's Thrush	0	1	1	0	0	0	1	0	1	2
Hermit Thrush	2	0	2	0	0	0	0	1	1	3
American Robin	2	0	2	0	0	0	0	0	0	2
Ruby-crowned Kinglet	7	48	55	6	42	48	3	48	51	154
MIMIC THRUSHES										
Northern Mockingbird	3	0	3	0	0	0	0	1	1	4

Table 2. Cont.

Common Name	1996 Spring	1996 Fall	1996 Total	1997 Spring	1997 Fall	1997 Total	1998 Spring	1998 Fall	1998 Total	Grand Total
WOOD WARBLERS										
Black and White Warbler	1	0	1	0	0	0	0	0	0	1
Prothonotary Warbler	0	0	0	0	1	1	0	0	0	1
Blue-winged Warbler	0	0	0	1	0	1	0	0	0	1
Golden-winged Warbler	0	0	0	2	0	2	0	0	0	2
Lucy's warbler	0	0	0	0	0	0	1	0	1	1
Virginia's Warbler	5	17	22	1	5	6	2	31	33	61
Nashville Warbler	2	0	2	0	0	0	0	0	0	2
Orange-crowned Warbler	10	10	20	1	11	12	5	128	133	165
Yellow Warbler	23	55	78	28	20	48	33	179	212	338
Yellow-rumped Warbler	47	23	70	0	0	0	10	34	44	114
Magnolia Warbler	1	0	1	0	0	0	0	0	0	1
Black-throated Gray Warbler	0	0	0	0	1	1	0	0	0	1
Townsend's Warbler	1	0	1	0	1	1	1	7	8	10
Prairie Warbler	1	0	1	0	0	0	0	0	0	1

Table 2. Cont.

Common Name	1996 Spring	1996 Fall	1996 Total	1997 Spring	1997 Fall	1997 Total	1998 Spring	1998 Fall	1998 Total	Grand Total
Northern Waterthrush	0	0	0	0	2	2	1	1	2	4
MacGillivray's Warbler	94	16	110	2	9	11	11	41	52	173
Common Yellowthroat	39	8	47	21	9	30	13	20	33	110
Yellow-breasted Chat	15	0	15	2	3	5	4	2	6	26
Wilson's Warbler	135	75	110	35	131	166	54	1017	1071	1347
American Redstart	0	0	0	0	1	1	0	1	1	2
TANAGERS										
Western Tanager	3	5	8	1	2	3	1	7	8	19
Summer Tanager	7	1	8	2	1	3	1	2	3	14
SPARROWS										
Vesper Sparrow	1	1	2	0	0	0	0	1	1	3
Savannah Sparrow	0	1	1	0	0	0	0	1	1	2
Lark Sparrow	3	6	9	0	1	1	0	13	13	23
White-crowned Sparrow	37	30	67	31	17	48	3	38	41	156
Chipping Sparrow	22	18	40	3	2	5	0	47	47	92
Clay-colored Sparrow	0	0	0	0	7	7	0	24	24	31

Table 2. Cont.

Common Name	1996 Spring	1996 Fall	1996 Total	1997 Spring	1997 Fall	1997 Total	1998 Spring	1998 Fall	1998 Total	Grand Total
Brewer's Sparrow	26	10	36	0	16	16	0	27	27	79
Dark-eyed Junco	6	16	22	0	3	3	1	22	23	48
Black-throated Sparrow	1	0	1	0	1	1	0	2	2	4
Sage Sparrow	0	0	0	0	2	2	0	1	1	3
Song Sparrow	1	35	36	1	10	11	0	23	23	70
Lincoln's Sparrow	10	15	25	3	13	16	2	13	15	56
Spotted Towhee	6	7	13	0	3	3	1	3	4	20
Green-tailed Towhee	9	1	10	0	2	2	0	2	2	14
Canyon Towhee	0	0	0	0	0	0	0	2	2	2
GROSBEAKS & BUNTING										
Pyrrhuloxia	0	1	1	0	0	0	0	0	0	1
Black-headed Grosbeak	13	0	13	5	0	5	9	2	11	29
Blue Grosbeak	19	4	23	4	10	14	1	12	13	50
Indigo Bunting	7	0	7	4	1	5	0	0	0	12
Lazuli Bunting	5	2	7	0	3	3	1	6	7	17
Painted Bunting	0	1	1	0	0	0	0	0	0	1

Table 2. Cont.

Common Name	1996 Spring	1996 Fall	1996 Total	1997 Spring	1997 Fall	1997 Total	1998 Spring	1998 Fall	1998 Total	Grand Total
BLACKBIRDS										
Brown-headed Cowbird	4	0	4	4	0	4	2	0	2	10
Northern Oriole	3	0	3	0	0	0	1	3	4	7
FINCHES										
House Finch	9	0	9	0	0	0	2	0	2	11
American Goldfich	2	0	2	0	0	0	0	0	0	2
Lesser Goldfinch	1	0	1	0	0	0	1	0	1	2

TABLE 3A RELATIVE ABUNDANCE OF MIGRATING LANDBIRDS AT BOSQUE DEL APACHE NWR SPRING 1994-1998

COMMON NAME	FAMILY NAME	GENUS NAME	SPECIES NAME	Average CAPTURE RATE/1000 NET-HRS	Average RANK
Wilson's Warbler	Parulidae	Wilsonia	pusilla	2.40	1.00
Dusky Flycatcher	Tyrannidae	Empidonax	oberholseri	0.82	3.33
Common Yellowthroat	Parulidae	Geothlypis	trichas	0.57	4.67
Yellow Warbler	Parulidae	Dendroica	petechia	0.57	5.00
White-crowned Sparrow	Emberizidae	Zonotrichia	leucophrys	0.79	5.33
MacGillivray's Warbler	Parulidae	Oporornis	tolmiei	1.20	5.67
Brewer's Sparrow	Emberizidae	Spizella	breweri	0.71	6.00
Audubon's Warbler	Parulidae	Dendroica	coronata	0.46	6.50
Warbling Vireo	Vireonidae	Vireo	gilvus	0.41	8.00
Black-headed Grosbeak	Cardinalidae	Pheucticus	melanocephalus	0.32	10.00
Ruby-crowned Kinglet	Regulidae	Regulus	calendula	0.30	11.00
Orange-crowned Warbler	Parulidae	Vermivora	celata	0.22	14.00
Willow Flycatcher	Tyrannidae	Empidonax	traillii	0.27	14.00
Chipping Sparrow	Emberizidae	Spizella	passerina	0.26	14.50
Bewick's Wren	Troglodytidae	Thryomanes	bewickii	0.17	15.33
Spotted Towhee	Emberizidae	Pipilo	erythrophthalmus	0.18	15.33
House Wren	Troglodytidae	Troglodytes	aedon	0.25	15.50
Yellow-breasted Chat	Parulidae	Icteria	virens	0.19	16.00
Blue Grosbeak	Cardinalidae	Guiraca	caerulea	0.19	17.33
Western Wood-Pewee	Tyrannidae	Contopus	sordidulus	0.16	18.00
Virginia's Warbler	Parulidae	Vermivora	virginiae	0.17	19.00
Ash-throated Flycatcher	Tyrannidae	Myiarchus	cinerascens	0.13	20.33
Green-tailed Towhee	Emberizidae	Pipilo	chlorurus	0.13	22.00
Summer Tanager	Thraupidae	Piranga	rubra	0.11	23.33
Lincoln's Sparrow	Emberizidae	Melospiza	lincolnii	0.18	27.00

TABLE 3B RELATIVE ABUNDANCE OF MIGRATING LANDBIRDS AT BOSQUE DEL APACHE NWR FALL 1994-1998

COMMON NAME	FAMILY NAME	GENUS NAME	SPECIES NAME	Average CAPTURE RATE/1000 NET-HRS	Average RANK
Wilson's Warbler	Parulidae	Wilsonia	pusilla	5.92	1.00
White-crowned Sparrow	Emberizidae	Zonotrichia	leucophrys	1.36	3.00
Ruby-crowned Kinglet	Regulidae	Regulus	calendula	0.97	4.00
Yellow Warbler	Parulidae	Dendroica	petechia	1.02	5.67
MacGillivray's Warbler	Parulidae	Oporornis	tolmiei	0.52	7.00
Chipping Sparrow	Emberizidae	Spizella	passerina	1.07	8.00
Lincoln's Sparrow	Emberizidae	Melospiza	lincolnii	0.55	8.00
Blue Grosbeak	Cardinalidae	Guiraca	caerulea	0.53	8.33
Orange-crowned Warbler	Parulidae	Vermivora	celata	0.83	8.33
Song Sparrow	Emberizidae	Melospiza	melodia	0.59	8.33
Oregon Junco	Emberizidae	Junco	hyemalis	0.53	9.33
Brewer's Sparrow	Emberizidae	Spizella	breweri	0.41	11.00
Audubon's Warbler	Parulidae	Dendroica	coronata	0.33	13.50
Warbling Vireo	Vireonidae	Vireo	gilvus	0.24	14.67
Spotted Towhee	Emberizidae	Pipilo	erythrophthalmus	0.20	16.33
Virginia's Warbler	Parulidae	Vermivora	virginiae	0.26	16.33
Bewick's Wren	Troglodytidae	Thryomanes	bewickii	0.18	17.33
Common Yellowthroat	Parulidae	Geothlypis	trichas	0.22	18.67
Summer Tanager	Thraupidae	Piranga	rubra	0.16	19.00
Lazuli Bunting	Cardinalidae	Passerina	amoena	0.16	19.33
Willow Flycatcher	Tyrannidae	Empidonax	traillii	0.16	19.33
Black-headed Grosbeak	Cardinalidae	Pheucticus	melanocephalus	0.15	23.00
Yellow-breasted Chat	Parulidae	Icteria	virens	0.06	23.00
Dusky Flycatcher	Tyrannidae	Empidonax	oberholseri	0.13	24.00
Western Wood-Pewee	Tyrannidae	Contopus	sordidulus	0.15	25.00

Table 4. Back colors of 138 willow flycatchers caught while migrating along the Middle Rio Grande between 1994 and 1998. Color numbers and descriptions refer to those in the Naturalist's Color Guide (Smythe 1975). Individuals were assigned to color categories by matching the color of their back feathers to the most similar color sample. Individuals were assigned to subspecies in the field. Numbers in parentheses are the percent of individuals in each color category that were assigned to each subspecies.

		Subspecies			
Color Number	Description	Adastus	Brewsteri	Extimus	Trailii
29	Brownish Olive	0	1 (1)	3 (10)	3 (43)
43	Grayish Olive	1 (5)	0	27 (84)	4 (57)
46	Olive Green	5 (28)	2 (2)	1 (3)	0
47	Olive Green	0	1 (1)	0	0
48	Olive Green	2 (11)	77 (95)	1 (3)	0
49	Greenish Olive	10 (56)	0	0	0

Table 5. Mean (sd) mass and wing, tail, and tarsus, lengths of willow flycatchers caught in the Bosque del Apache in 1996 and 1997. N is number of birds measured.

			Mass (g)		Wing (cm)		Tail(cm)		Tarsus (cm)	
			x̄ (sd)	n	x̄ (sd)	n	x̄ (sd)	n	x̄ (sd)	n
1996.00	FA	AG	13.0 (---)	1	66.0 (---)	1	56.0 (---)	1	18.5 (---)	1
		CO	--- (---)	0	66.5 (0.7)	2	55.5 (0.7)	2	16.5 (0.8)	2
		LF	11.4 (1.0)	8	66.7 (3.4)	8	54.4 (4.2)	8	15.4 (1.3)	8
		SS	12.6 (0.8)	7	65.9 (2.0)	7	55.7 (2.0)	6	16.2 (1.4)	7
		SW	12.1 (0.6)	4	67.2 (1.8)	5	53.8 (2.4)	5	16.6 (1.0)	5
	SP	AG	11.9 (0.4)	2	68.2 (2.5)	2	58.5 (2.1)	2	16.0 (0.3)	
		CO	--- (---)	0	--- (---)	0	--- (----)	0	--- (----)	0
		LF	12.1 (0.8)	12	67.3 (3.1)	13	56.7 (1.8)	13	16.4 (0.7)	13
		SS	12.9 (---)	1	68.0 (---)	1	59.0 (----)	1	16.8 (----)	1
		SW	12.1 (1.0)	11	68.1 (3.3)	11	58.1 (2.8)	11	16.5 (0.9)	11
1997.00	FA	AG	14.2 (----)	1	70.0 (----)	1	58.0 (----)	1	16.6 (----)	
		CO	--- (----)	0	--- (----)	0	--- (----)	0	--- (----)	0
		LF	11.3 (0.8)	7	66.1 (2.6)	7	55.6 (3.2)	7	15.5 (1.7)	7
		SS	12.3 (0.5)	2	65.0 (4.2)	2	55.0 (2.8)	2	15.5 (0.2)	2
		SW	11.5 (0.2)	3	65.3 (3.1)	3	53.3 (2.9)	3	16.0 (0.2)	3
	SP	AG	--- (----)	0	--- (----)	0	--- (----)	0	--- (----)	0
		CO	12.1 (1.5)	4	72.6 (3.0)	4	61.3 (3.9)	4	16.8 (0.6)	4
		LF	12.8 (0.9)	13	69.5 (3.3)	13	57.2 (3.5)	13	16.5 (0.8)	13
		SS	12.4 (0.6)	6	69.0 (2.5)	7	59.4 (3.1)	7	16.4 (1.1)	7
		SW	13.5 (1.2)	5	69.4 (2.9)	5	57.8 (2.6)	5	16.6 (0.8)	5

Table 6. Vegetative cover measured in 0.04 ha circular plots surrounding mist-nets in the Bosque del Apache NWR

Habitat	N	%Shrub Cover $\bar{x}$ (range)	% Overstory Cover $\bar{x}$ (range)	% Litter $\bar{x}$ (range)	% Bare Ground $\bar{x}$ (range)	Stems < 3 in. DBH $\bar{x}$ (range)
Agricultural edge	3	28 (2-65)	57 (0-85)	8 (5-15)	5 (0-15)	N/A
Cottonwood	7	35 (10-70)	23 (0-55)	29 (5-55)	8 (5-10)	N/A
Low Flow Channel	15	46 (37-55)	0 (0-0)	19 (5-40)	5 (1-15)	1168 (850-1500)
Willow	4	50 (39-58)	0 (0-0)	21 (18-22)	8 (4-15)	595 (130-1000)
Saltcedar	8	57 (35-85)	0 (0-0)	8 (3-20)	18 (3-30)	1199 (320-2100)

TABLE 7 RIPARIAN VEGETATION IN THE BOSQUE DEL APACHE NWR
PRIOR TO SAN ANTONIO FIRE OF JUNE 1996

HABITAT GROUP	STRUCTURE	BURNED	ACRES
COTTONWOOD	1	NO	3,427.08
COTTONWOOD	1	YES	5,438.87
COTTONWOOD	2	NO	46.27
COTTONWOOD	3	NO	4,278.14
COTTONWOOD	3	YES	1,264.37
COTTONWOOD	4	NO	4,526.85
COTTONWOOD	4	YES	1,570.60
COTTONWOOD	5	NO	4,297.49
COTTONWOOD	5	YES	1,585.32
COTTONWOOD	6	NO	1,504.33
COTTONWOOD	6	YES	17.27
MESQUITE	6	NO	4,936.76
RUSSIAN OLIVE	5	NO	827.48
SALT CEDAR	3	NO	8,797.09
SALT CEDAR	3	YES	1,460.54
SALT CEDAR	4	NO	3,850.24
SALT CEDAR	4	YES	310.04
SALT CEDAR	5	NO	14,703.15
SALT CEDAR	5	YES	6,833.41
SALT CEDAR	6	NO	11,299.92
SALT CEDAR	6	YES	608.10
SALTBUSH	6	NO	2,877.80
WILLOW	4	NO	85.97
WILLOW	5	NO	90.80
WILLOW	5	YES	115.85
WILLOW	6	NO	15.07
ALL		YES	19,204.00
ALL		NO	65,564.00

Table 8: Yearly and seasonal trends in numbers of arthropods captured per ten sample days at Bosque del Apache National Wildlife Refuge. Data are from a subset of traps/sampling events repeated all years.

	1996		1997		1998	
Traps	Spring	Fall	Spring	Fall	Spring	Fall
Glueboard	320.3	377.0	665.5	287.6	1378.2	607.4
Pitfall	67.3	345.1	89.9	399.0	926.5	2065.3
Sweep (shrub)	--	--	90.5	58.7	260.7	126.6
Sweep (herbs)	--	--	150.4	80.4	350.0	183.6
Mistnet	--	--	44.4	59.4	1730.0	55.3

APPENDIX 1. SPECIES ENCOUNTERED DURING BIRD MIGRATION STUDY
BOSQUE DEL APACHE NWR 1994-1998 USFS RESEARCH

AOU#	COMMON NAME	FAMILY GROUP	FAMILY NAME	GENUS NAME	SPECIES NAME	SUB SPECIES NAME	MIGRATION STATUS
3160	Mourning Dove	Dove	Columbidae	Zenaida	macroura		SHORT DISTANCE
3200	Common Ground-Dove	Dove	Columbidae	Columbina	passerina		RESIDENT
3320	Sharp-shinned Hawk	Hawk	Accipitridae	Accipiter	striatus		SHORT DISTANCE
3330	Cooper's Hawk	Hawk	Accipitridae	Accipiter	cooperii		SHORT DISTANCE
3600	American Kestrel	Falcon	Falconidae	Falco	sparverius		SHORT DISTANCE
3850	Greater Roadrunner	Cuckoo	Cuculidae	Geococcyx	californianus		RESIDENT
3870	Yellow-billed Cuckoo	Cuckoo	Cuculidae	Coccyzus	americanus		NEOTROPICAL
3900	Belted Kingfisher	Kingfisher	Alcedinidae	Ceryle	alcyon		SHORT DISTANCE
3930	Hairy Woodpecker	Woodpecker	Picidae	Picoides	villosus		SHORT DISTANCE
3940	Downy Woodpecker	Woodpecker	Picidae	Picoides	scalaris		SHORT DISTANCE
3960	Ladder-backed Woodpecker	Woodpecker	Picidae	Picoides	Scalaris		SHORT DISTANCE
4021	Red-naped Sapsucker	Woodpecker	Picidae	Sphyrapicus	varius		SHORT DISTANCE
4040	Williamson's Sapsucker	Woodpecker	Picidae	Sphyrapicus	thyroideus		SHORT DISTANCE
4130	Red-shafted Flicker	Woodpecker	Picidae	Colaptes	auratus	Red-shafted	SHORT DISTANCE
4470	Western Kingbird	Flycatcher	Tyrannidae	Tyrannus	verticalis		NEOTROPICAL
4530	Brown-crested Flycatcher	Flycatcher	Tyrannidae	Myiarchus	tyrannulus		CROSS BORDER
4540	Ash-throated Flycatcher	Flycatcher	Tyrannidae	Myiarchus	cinerascens		NEOTROPICAL
4570	Say's Phoebe	Flycatcher	Tyrannidae	Sayornis	saya		SHORT DISTANCE
4580	Black Phoebe	Flycatcher	Tyrannidae	Sayornis	nigricans		SHORT DISTANCE
4590	Olive-sided Flycatcher	Flycatcher	Tyrannidae	Contopus	borealis		NEOTROPICAL
4610	Eastern Wood-Pewee	Flycatcher	Tyrannidae	Contopus	virens		NEOTROPICAL
4620	Western Wood-Pewee	Flycatcher	Tyrannidae	Contopus	sordidulus		NEOTROPICAL
4649	Western Flycatcher	Flycatcher	Tyrannidae	Empidonax	difficilis		NEOTROPICAL
4650	Acadian Flycatcher	Flycatcher	Tyrannidae	Empidonax	virescens		NEOTROPICAL
4660	Willow Flycatcher	Flycatcher	Tyrannidae	Empidonax	traillii		NEOTROPICAL
4680	Hammond's Flycatcher	Flycatcher	Tyrannidae	Empidonax	hammondii		NEOTROPICAL
4690	Dusky Flycatcher	Flycatcher	Tyrannidae	Empidonax	oberholseri		NEOTROPICAL
4691	Gray Flycatcher	Flycatcher	Tyrannidae	Empidonax	wrightii		NEOTROPICAL
4810	Scrub Jay	Jay	Corvidae	Aphelocoma	coerulescens		SHORT DISTANCE
4810	Western Scrub-Jay	Jay	Corvidae	Aphelocoma	californica	Western	RESIDENT
4930	European Starling	Starling	Sturnidae	Sturnus	vulgaris		SHORT DISTANCE
4950	Brown-headed Cowbird	Blackbird	Icteridae	Molothrus	ater		SHORT DISTANCE
4970	Yellow-headed Blackbird	Blackbird	Icteridae	Xanthocephalus	xanthocephalus		NEOTROPICAL
4980	Red-winged Blackbird	Blackbird	Icteridae	Agelaius	phoeniceus		SHORT DISTANCE
5080	Bullock's Oriole	Oriole	Icteridae	Icterus	galbula	Bullock's	SHORT DISTANCE
5190	House Finch	Finch	Fringillidae	Carpodacus	mexicanus		SHORT DISTANCE
5290	American Goldfinch	Finch	Fringillidae	Carduelis	tristis		SHORT DISTANCE
5300	Lesser Goldfinch	Finch	Fringillidae	Carduelis	psaltria		SHORT DISTANCE
5330	Pine Siskin	Finch	Fringillidae	Caduelis	pinus		SHORT DISTANCE
5400	Vesper Sparrow	Sparrow	Emberizidae	Pooecetes	gramineus		SHORT DISTANCE
5420	Savannah Sparrow	Sparrow	Emberizidae	Passerculus	sandwichensis		SHORT DISTANCE

APPENDIX 1. SPECIES ENCOUNTERED DURING BIRD MIGRATION STUDY
BOSQUE DEL APACHE NWR 1994-1998 USFS RESEARCH

AOU#	COMMON NAME	FAMILY GROUP	FAMILY NAME	GENUS NAME	SPECIES NAME	SUB SPECIES NAME	MIGRATION STATUS
5520	Lark Sparrow	Sparrow	Emberizidae	Chondestes	grammacus		NEOTROPICAL
5530	Harris' Sparrow	Sparrow	Emberizidae	Zonotrichia	guerula		SHORT DISTANCE
5540	White-crowned Sparrow	Sparrow	Emberizidae	Zonotrichia	leucophrys		SHORT DISTANCE
5546	Mountain White-crowned Sparrc	Sparrow	Emberizidae	Zonotrichia	leucophrys	oriantha	SHORT DISTANCE
5550	Gambel's White-crowned Sparr	Sparrow	Emberizidae	Zonotrichia	leucophrys	gambelii	SHORT DISTANCE
5580	White-throated Sparrow	Sparrow	Emberizidae	Zonotrichia	albicollis		SHORT DISTANCE
5600	Chipping Sparrow	Sparrow	Emberizidae	Spizella	passerina		NEOTROPICAL
5610	Clay-colored Sparrow	Sparrow	Emberizidae	Spizella	pallida		NEOTROPICAL
5620	Brewer's Sparrow	Sparrow	Emberizidae	Spizella	breweri		NEOTROPICAL
5670	Slate-colored Junco	Sparrow	Emberizidae	Junco	hyemalis	Slate-colored	SHORT DISTANCE
5671	Oregon Junco	Sparrow	Emberizidae	Junco	hyemalis		SHORT DISTANCE
5677	Dark-eyed Junco	Sparrow	Emberizidae	Junco	hyemalis		SHORT DISTANCE
5690	Gray-headed Junco	Sparrow	Emberizidae	Junco	caniceps		SHORT DISTANCE
5730	Black-throated Sparrow	Sparrow	Emberizidae	Amphispiza	bilineata		SHORT DISTANCE
5740	Sage Sparrow	Sparrow	Emberizidae	Amphispiza	belli		SHORT DISTANCE
5810	Song Sparrow	Sparrow	Emberizidae	Melospiza	melodia		SHORT DISTANCE
5830	Lincoln's Sparrow	Sparrow	Emberizidae	Melospiza	lincolnii		NEOTROPICAL
5840	Swamp Sparrow	Sparrow	Emberizidae	Melospiza	georgiana		SHORT DISTANCE
5850	Fox Sparrow	Sparrow	Emberizidae	Passerella	iliaca		SHORT DISTANCE
5880	Spotted Towhee	Sparrow	Emberizidae	Pipilo	erythrophthalmus		SHORT DISTANCE
5900	Green-tailed Towhee	Sparrow	Emberizidae	Pipilo	chlorurus		NEOTROPICAL
5910	Canyon Towhee	Sparrow	Emberizidae	Pipilo	fuscus	Canyon	SHORT DISTANCE
5940	Pyrrhuloxia	Cardinal	Cardinalidae	Cardinalis	sinuatus		RESIDENT
5950	Rose-breasted Grosbeak	Cardinal	Cardinalidae	Pheucticus	ludovicianus		NEOTROPICAL
5960	Black-headed Grosbeak	Cardinal	Cardinalidae	Pheucticus	melanocephalus		NEOTROPICAL
5970	Blue Grosbeak	Cardinal	Cardinalidae	Guiraca	caerulea		NEOTROPICAL
5980	Indigo Bunting	Cardinal	Cardinalidae	Passerina	cyanea		NEOTROPICAL
5990	Lazuli Bunting	Cardinal	Cardinalidae	Passerina	amoena		NEOTROPICAL
6010	Painted Bunting	Cardinal	Cardinalidae	Passerina	ciris		NEOTROPICAL
6050	Lark Bunting	Sparrow	Emberizidae	Calamospiza	melanocorys		NEOTROPICAL
6070	Western Tanager	Tanager	Thraupidae	Piranga	ludoviciana		NEOTROPICAL
6090	Hepatic Tanager	Tanager	Thraupidae	Piranga	flava		NEOTROPICAL
6100	Summer Tanager	Tanager	Thraupidae	Piranga	rubra		NEOTROPICAL
6130	Barn Swallow	Swallow	Hirundinidae	Hirundo	rustica		NEOTROPICAL
6150	Violet-green Swallow	Swallow	Hirundinidae	Tachycineta	thalassina		NEOTROPICAL
6170	Northern Rough-winged Swallov	Swallow	Hirundinidae	Stelgidopteryx	serripennis		NEOTROPICAL
6240	Red-eyed Vireo	Vireo	Vireonidae	Vireo	olivaceus		NEOTROPICAL
6270	Warbling Vireo	Vireo	Vireonidae	Vireo	gilvus		NEOTROPICAL
6280	Yellow-throated Vireo	Vireo	Vireonidae	Vireo	flavifrons		NEOTROPICAL
6290	Blue-headed Vireo	Vireo	Vireonidae	Vireo	solitarius		NEOTROPICAL
6291	Plumbeous Vireo	Vireo	Vireonidae	Vireo	plumbeus		NEOTROPICAL
6292	Cassin's Vireo	Vireo	Vireonidae	Vireo	cassinii		NEOTROPICAL
6300	Solitary Vireo	Vireo	Vireonidae	Vireo	solitarius		NEOTROPICAL

APPENDIX 1. SPECIES ENCOUNTERED DURING BIRD MIGRATION STUDY
BOSQUE DEL APACHE NWR 1994-1998 USFS RESEARCH

AOU#	COMMON NAME	FAMILY GROUP	FAMILY NAME	GENUS NAME	SPECIES NAME	SUB SPECIES NAME	MIGRATION STATUS
6310	White-eyed Vireo	Vireo	Vireonidae	Vireo	griseus		NEOTROPICAL
6340	Gray Vireo	Vireo	Vireonidae	Vireo	vicinior		NEOTROPICAL
6360	Black-and-white Warbler	Warbler	Parulidae	Mniotilta	varia		NEOTROPICAL
6370	Prothonotary Warbler	Warbler	Parulidae	Protonotaria	citrea		NEOTROPICAL
6410	Blue-winged Warbler	Warbler	Parulidae	Vermivora	pinus		NEOTROPICAL
6420	Golden-winged Warbler	Warbler	Parulidae	Vermivora	chrysoptera		NEOTROPICAL
6430	Lucy's Warbler	Warbler	Parulidae	Vermivora	luciae		CROSS BORDER
6440	Virginia's Warbler	Warbler	Parulidae	Vermivora	virginiae		NEOTROPICAL
6450	Nashville Warbler	Warbler	Parulidae	Vermivora	ruficapilla		NEOTROPICAL
6460	Orange-crowned Warbler	Warbler	Parulidae	Vermivora	celata		NEOTROPICAL
6480	Northern Parula	Warbler	Parulidae	Parula	americana		NEOTROPICAL
6520	Yellow Warbler	Warbler	Parulidae	Dendroica	petechia		NEOTROPICAL
6540	Black-throated Blue Warbler	Warbler	Parulidae	Dendroica	caerulescens		NEOTROPICAL
6550	Myrtle Warbler	Warbler	Parulidae	Dendroica	coronata	Myrtle	SHORT DISTANCE
6556	Yellow-rumped Warbler	Warbler	Parulidae	Dendroica	coronata		SHORT DISTANCE
6560	Audubon's Warbler	Warbler	Parulidae	Dendroica	coronata	Audubon's	SHORT DISTANCE
6570	Magnolia Warbler	Warbler	Parulidae	Dendroica	magnolia		NEOTROPICAL
6590	Chestnut-sided Warbler	Warbler	Parulidae	Dendroica	pensylvanica		NEOTROPICAL
6600	Bay-breasted Warbler	Warbler	Parulidae	Dendroica	castanea		NEOTROPICAL
6650	Black-throated Gray Warbler	Warbler	Parulidae	Dendroica	nigrescens		NEOTROPICAL
6680	Townsend's Warbler	Warbler	Parulidae	Dendroica	townsendi		NEOTROPICAL
6730	Prairie Warbler	Warbler	Parulidae	Dendroica	discolor		NEOTROPICAL
6740	Ovenbird	Warbler	Parulidae	Seiurus	aurocapillus		NEOTROPICAL
6750	Northern Waterthrush	Warbler	Parulidae	Seiurus	noveboracensis		NEOTROPICAL
6770	Kentucky Warbler	Warbler	Parulidae	Oporornis	formosus		NEOTROPICAL
6790	Mourning Warbler	Warbler	Parulidae	Oporornis	philadelphia		NEOTROPICAL
6800	MacGillivray's Warbler	Warbler	Parulidae	Oporornis	tolmiei		NEOTROPICAL
6810	Common Yellowthroat	Warbler	Parulidae	Geothlypis	trichas		NEOTROPICAL
6830	Yellow-breasted Chat	Warbler	Parulidae	Icteria	virens		NEOTROPICAL
6840	Hooded Warbler	Warbler	Parulidae	Wilsonia	citrina		NEOTROPICAL
6850	Wilson's Warbler	Warbler	Parulidae	Wilsonia	pusilla		NEOTROPICAL
6860	Canada Warbler	Warbler	Parulidae	Wilsonia	canadensis		NEOTROPICAL
6870	American Redstart	Warbler	Parulidae	Setophaga	ruticilla		NEOTROPICAL
7030	Northern Mockingbird	Mimic Thrush	Mimidae	Mimus	polyglottos		SHORT DISTANCE
7040	Gray Catbird	Mimic Thrush	Mimidae	Dumetella	carolinensis		NEOTROPICAL
7050	Brown Thrasher	Mimic Thrush	Mimidae	Toxostoma	rufum		SHORT DISTANCE
7120	Crissal Thrasher	Mimic Thrush	Mimidae	Toxostoma	dorsale		RESIDENT
7130	Cactus Wren	Wren	Troglodytidae	Campylorhynchus	brunneicapillus		RESIDENT
7150	Rock Wren	Wren	Troglodytidae	Salpinctes	obsoletus		SHORT DISTANCE
7180	Carolina Wren	Wren	Troglodytidae	Thryothorus	ludovicianus		RESIDENT
7190	Bewick's Wren	Wren	Troglodytidae	Thryomanes	bewickii		SHORT DISTANCE
7210	House Wren	Wren	Troglodytidae	Troglodytes	aedon		NEOTROPICAL
7220	Winter Wren	Wren	Troglodytidae	Troglodytes	troglodytes		SHORT DISTANCE

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BOSQUE DEL APACHE NWR 1994-1998 USFS RESEARCH

AOU#	COMMON NAME	FAMILY GROUP	FAMILY NAME	GENUS NAME	SPECIES NAME	SUB SPECIES NAME	MIGRATION STATUS
7250	Marsh Wren	Wren	Troglodytidae	Cistothorus	palustris		SHORT DISTANCE
7260	Brown Creeper	Creeper	Certhiidae	Certhia	americana		SHORT DISTANCE
7270	White-breasted Nuthatch	Nuthatch	Sittidae	Sitta	carolinensis		SHORT DISTANCE
7280	Red-breasted Nuthatch	Nuthatch	Sittidae	Sitta	canadensis		SHORT DISTANCE
7380	Mountain Chickadee	Chickadee	Paridae	Parus	gambelli		SHORT DISTANCE
7430	Bushtit	Bushtit	Aegithalidae	Psaltriparus	minimus		SHORT DISTANCE
7460	Verdin	Verdin	Remizidae	Auriparus	flaviceps		SHORT DISTANCE
7480	Golden-crowned Kinglet	Kinglet	Regulidae	Regulus	satrapa		SHORT DISTANCE
7490	Ruby-crowned Kinglet	Kinglet	Regulidae	Regulus	calendula		SHORT DISTANCE
7510	Blue-gray Gnatcatcher	Gnatcatcher	Sylviidae	Polioptila	caerulea		SHORT DISTANCE
7540	Townsend's Solitaire	Thrush	Turdidae	Myadestes	townsendi		SHORT DISTANCE
7580	Swainson's Thrush	Thrush	Turdidae	Catharus	ustulatus		NEOTROPICAL
7590	Hermit Thrush	Thrush	Turdidae	Catharus	guttatus		SHORT DISTANCE
7610	American Robin	Thrush	Turdidae	Turdus	migratorius		SHORT DISTANCE

Appendix 2: Taxa identified to Order, Suborder, Superfamily, or Family using glueboard, mistnet, pitfall, and sweep sampling techniques at all trap sites. Arrangement is phylogenetic for Order and Family listings.

Order Suborder	Superfamily	Family	Common Name
Scolopendromorpha			Centipedes
Solifugae		Eremobatidae	Sun spiders, solpugids
Psuedoscorpionida			Psuedoscorpions
Araneae		Pholcidae	Cellar spiders
		Dysderidae	Dysderid spiders
		Mimetidae	Pirate spiders
		Linyphiidae	Sheet-web spiders
		Tetragnathidae	Long-jawed orb-weaving spiders
		Araneidae	Orb-weaving spiders
		Lycosidae	Wolf spiders
		Agelenidae	Funnel weaving spiders
		Dictynidae	Dictynid spiders
		Oxyopidae	Lynx spiders
		Anyphaenidae	Sac spiders
		Clubionidae	Sac spiders
		Corinnidae	Corinnid spiders
		Gnaphosidae	Ground spiders
		Philodromidae	Running spiders
		Thomisidae	Crab spiders
		Salticidae	Jumping spiders
Opiliones		Phalangidae	Daddy-longlegs
Acari			Mites
Isopoda		Armadilliidae	Pillbugs
		Porcellionidae	Sowbugs
Collembola		Hypogastruridae	Springtails
		Isotomidae	Springtails
		Entomobryidae	Springtails
		Sminthuridae	Globular springtails
Microcoryphia		Machilidae	Bristletails
		Meinertellidae	Bristletails

Order Suborder	Superfamily	Family	Common Name
Ephemeroptera		Baetidae	Small mayflies
		Heptageniidae	Stream mayflies
		Leptophlebiidae	Leptophlebiid mayflies
Odonata		Aeshnidae	Darners
		Coenagrionidae	Narrow-winged damselflies
Mantodea		Mantidae	Praying mantids
Phasmatodea		Heteronemiidae	Walkingsticks
Orthoptera		Acrididae	Short-horned grasshoppers
		Tettigoniidae	Long-horned grasshoppers
		Rhaphidophoridae	Camel crickets
		Gryllidae	Crickets
Isoptera		Rhinotermitidae	Termites
Plecoptera			Stoneflies
Dermaptera			Earwigs
Heteroptera		Cydnidae	Burrower bugs
(Hemiptera)		Thyreocoridae	Negro bugs
		Pentatomidae	Stinkbugs
		Scutelleridae	Shield-backed bugs
		Rhopalidae	Scentless plant bugs
		Lygaeidae	Seed bugs
		Berytidae	Stilt bugs
		Tingidae	Lace bugs
		Phymatidae	Ambush bugs
		Reduviidae	Assassin bugs
		Nabidae	Damsel bugs
		Anthocoridae	Minute pirate bugs
		Miridae	Leaf or plant bugs
Homoptera			
	Auchenorrhyncha	Cixiidae	Cixiid planthoppers
		Delphacidae	Delphacid planthoppers
		Dictyopharidae	Dictyopharid planthoppers
		Cercopidae	Froghoppers

Order	Suborder	Superfamily	Family	Common Name
			Cicadidae	Cicadas
			Cicadellidae	Leafhoppers
			Membracidae	Treehoppers
	Sternorrhyncha			
			Psyllidae	Psyllids
			Aphididae	Aphids
Thysanoptera			Thripidae	Common thrips
Psocoptera			Liposcelidae	Liposcelid booklice
Neuroptera			Chrysopidae	Green lacewings
			Myrmeleontidae	Antlions
Coleoptera				
	Adephaga		Carabidae	Ground beetles
	Polyphaga			
		Hydrophiloidea	Histeridae	Hister beetles
		Staphylinoidea	Staphylinidae	Rove beetles
		Scarabaeoidea	Scarabaeidae	Scarab beetles
		Buprestoidea	Buprestidae	Metallic wood-borers
		Elateroidea	Elateridae	Click beetles
			Lampyridae	Fireflies
		Bostrichoidea	Dermestidae	Dermestid beetles
		Cleroidea	Trogositidae	Bark-gnawing beetles
			Cleridae	Checkered beetles
			Melyridae	Soft-winged flower beetles
		Cucujoidea	Nitidulidae	Sap beetles
			Montomidae	Montomid beetles
			Cucujidae	Flat bark beetles
			Phalacridae	Shining mold beetles
			Cryptophagidae	Silken fungus beetles
			Coccinellidae	Ladybird beetles
		Tenebrionoidea	Melandryidae	False darkling beetles
			Mordellidae	Tumbling flower beetles
			Tenebrionidae	Darkling beetles
			Anthicidae	Ant-like flower beetles
			Scraptiidae	Scraptiid beetles
		Chrysomeloidea	Cerambycidae	Long-horned beetles
			Chrysomelidae	Leaf beetles
		Curculionoidea	Curculionidae	Snout beetles (weevils)

Order Suborder	Superfamily	Family	Common Name
Diptera			
	Tipuloidea	Tipulidae	Crane flies
	Bibionoidea	Bibionidae	March flies
	Sciaroidea	Mycetophilidae	Fungus gnats
		Sciaridae	Dark-winged fungus gnats
		Cecidomyiidae	Gall gnats
	Psychodoidea	Psychodidae	Moth flies
	Scatopsoidea	Scatopsidae	Minute black scavenger flies
	Culicoidea	Dixidae	Dixiid midges
		Culicidae	Mosquitos
	Chironomoidea	Simuliidae	Black flies
		Ceratopogonidae	Punkies, biting midges
		Chironomidae	Midges
	Tabanoidea	Tabanidae	Deer flies
		Rhagionidae	Snipe flies
	Stratiomyoidea	Xylophagidae	Xylophagid flies
		Xylomyidae	Xylomid flies
		Stratiomyidae	Soldier flies
	Asiloidea	Therevidae	Stiletto flies
		Scenopinidae	Window flies
		Asilidae	Robber flies
	Bombyloidea	Acroceridae	Small-headed flies
		Bombyliidae	Bee flies
	Empidoidea	Empididae	Dance flies
		Dolichopodidae	Long-legged flies
	Platypezoidea	Phoridae	Hump-backed flies
	Syrphidoidea	Syrphidae	Syrphid flies
		Pipunculidae	Big-headed flies
	Conopoidea	Conopidae	Thick-headed flies
	Nerioidea	Micropezidae	Stilt-legged flies
	Tephritoidea	Lonchaeidae	Lonchaeid flies
		Otitidae	Picture-winged flies
		Tephritidae	Fruit flies
		Piophilidae	Skipper flies
	Opomyzoidea	Agromyzidae	Leaf miner flies
	Sciomyzoidea	Sciomyzidae	Marsh flies
		Sepsidae	Black scavenger flies
	Lauxanioidea	Lauxaniidae	Lauxaniid flies
		Chamaemyiidae	Chamaemyiid flies
	Sphaeroceroidea	Heleomyzidae	Heleomyzid flies

Order Suborder	Superfamily	Family	Common Name
		Trixoscelididae	Trixoscelidid flies
	Ephydroidea	Drosophilidae	Pomace flies
		Diastatidae	Diastatid flies
		Chloropidae	Frit flies
	Muscoidea	Anthomyiidae	Anthomyiid flies
		Muscidae	House flies
	Oestroidea	Calliphoridae	Blow flies
		Tachinidae	Tachnid flies
Trichoptera		Hydroptilidae	Caddisflies
		Limnephilidae	Northern caddisflies
Mecoptera			Scorpionflies
Lepidoptera			
	Gelechioidea	Gelechiidae	Gelechiid moths
	Tortricoidea	Tortricidae	Tortricid moths
	Hesperioidea	Hesperiidae	Common skippers
	Papilionoidea	Papilionidae	Swallowtail butterflies
		Pieridae	Whites and sulfurs
		Nymphalidae	Brush-footed butterflies
		Danaidae	Milkweed butterflies
	Pterophoroidea	Pterophoridae	Plume moths
	Geometroidea	Geometridae	Geometer moths
	Sphingoidea	Sphingidae	Sphinx moths
	Noctuoidea	Arctiidae	Tiger moths
		Noctuidae	Noctuid moths
Hymenoptera			
	Siricoidea	Siricidae	Horntails
	Ichneumonoidea	Braconidae	Braconid wasps
		Ichneumonidae	Ichneumon wasps
	Chalcidoidea	Torymidae	Torymid wasps
		Pteromalidae	Parasitic wasps
		Perilampidae	Perilampid wasps
		Encyrtidae	Encyrtid wasps
		Eulophidae	Eulophid wasps
		Myrmaridae	Fairyflies
	Cynipoidea	Cynipidae	Gall wasps
	Proctotrupoidea	Diapriidae	Diapriid wasps
		Scelionidae	Scelionid wasps
		Platygastridae	Platygastrid wasps

Order Suborder	Superfamily	Family	Common Name
		Proctotrupidae	Proctotrupid wasps
	Ceraphronoidea	Ceraphronididae	Ceraphronid wasps
	Chrysidoidea	Bethylidae	Bethylid wasps
		Chrysididae	Cuckoo wasps
		Dryinidae	Dryinid wasps
	Scolioidea	Tiphiidae	Tiphiid wasps
		Mutillidae	Velvet ants
	Formicoidea	Formicidae	Ants
	Vespoidea	Vespidae	Vespid wasps
	Pompilioidea	Pompilidae	Spider wasps
	Sphecoidea	Sphecidae	Sphecid or thread-waisted wasps
	Apoidea	Colletidae	Yellow-faced bees
		Andrenidae	Andrenid bees
		Halictidae	Sweat bees
		Apidae	Bumble bees, honey bees, etc.

Appendix 3: Spring numbers of arthropods captured per 10 sample days in the low flow conveyance channel willows (LFCC) during three years in Bosque del Apache National Wildlife Refuge. For each trapping method, included a subset of traps/sampling events repeated all years. See Appendix 2 for common names.

Orders	1996		1997				1998			
	Glue-board	Pitfall	Glue-board	Pitfall	Shrub Sweep	Mistnet	Glue-board	Pitfall	Shrub Sweep	Mistnet
Acari	0	0	0	0	0	0	0	0	0	0
Araneae	0	0.9	6.4	0.4	6.7	0	0.6	0.2	15.6	1.8
Collembola	0	0	0	0.9	0	0	0	0	0	0
Coleoptera	29.2	2.7	11.4	0.7	13.3	5.0	20.0	1.1	5.0	1.8
Dermaptera	0	0	0	0	0	0	0	0	0	0
Diptera	282.5	5.9	364.3	4.7	34.0	10.0	1437.2	1.3	265.6	10.9
Ephemeroptera	0	0	0	0.2	0	1.7	0	0	0	0
Hemiptera	5.0	0.5	2.9	0	8.7	0	7.2	0.2	11.1	5.5
Homoptera	18.3	0.9	39.3	0.2	25.3	0	131.1	0.2	128.3	0
Hymenoptera	83.3	1.4	165.7	18.7	40.0	6.7	174.4	2.2	107.8	12.7
Isopoda	0	0	0	0	0	0	0	0.3	0	0
Isoptera	0	0	0	0	0	0	0	0	0	0
Lepidoptera	0	0	8.6	0	2.0	1.7	7.2	0	1.7	3.6
Microcoryphia	0	6.4	0	0.7	0	0	0	0.6	0	0
Mecoptera	0	0.5	0	0	0	0	0	0	0	0
Neuroptera	0	0	0	0	0	1.7	0	0	0	0
Odonata	0	0	0.7	0	0	15.0	0	0	0	5.5
Opiliones	0	0	0	0	0	0	0	0	0	0
Orthoptera	0	1.8	0.7	0.2	1.3	0	0	0.9	3.9	0
Plecoptera	0	0	0	0	0	0	0	0	1.1	0
Pseudoscorpiones	0	0	0	0	0	0	0	0	0	0
Psocoptera	0	0	0	0.4	0	0	0	0	0	0
Solifugae	0	0	0	0	0	0	0	0	0	0
Thysanoptera	31.7	0	40.7	0	8.0	0	397.2	0	0	0
Trichoptera	0	0	0	0	0	0	2.8	0	0.6	0
Unknown	3.3	0	0	0	0	0	0	0	0	0

Appendix 4: Fall numbers of arthropods captured per 10 trap days in the low flow conveyance channel willows (LFCC) during three years in Bosque del Apache National Wildlife Refuge. For each trapping method, included a subset of traps/sampling events repeated all years. See Appendix 2 for common names.

Orders	1996		1997				1998			
	Glue-board	Pitfall	Glue-board	Pitfall	Shrub sweep	Mistnet	Glue-board	Pitfall	Shrub sweep	Mistnet
Acari	0.4	0.3	0	0	0	0	0	0.5	0	0
Araneae	0.8	1.3	1.1	1.7	4.8	1.4	3.3	1.3	5.2	1.4
Collembola	0	0	0	0	0	0	0	43.0	0	0
Coleoptera	4.2	1.1	2.6	1.1	1.9	17.4	6.2	1.6	4.3	13.6
Dermaptera	0	0	0	0	0	0	0	0	0	0
Diptera	219.6	3.0	33.2	1.4	5.2	1.1	115.0	3.0	19.5	2.9
Ephemeroptera	0	0	0	0	0	0	0	0	0	0
Hemiptera	2.1	0	14.7	0.4	1.3	0	14.2	0.0	4.3	0.2
Homoptera	25.4	0.8	73.2	0.8	12.6	4.0	76.7	0.2	13.3	3.1
Hymenoptera	42.9	5.4	39.5	4.8	5.8	3.4	56.2	8.3	19.1	2.4
Isopoda	0	0.3	0	0.1	0.3	0	0	57.5	0	0
Isoptera	0	0	0	0	0	0	0	0	0	0
Lepidoptera	2.9	0	1.6	0.1	0	0.9	2.5	0	0.5	1.9
Microcoryphia	0	0.3	0	0.1	0	0	0	0	0	0
Mecoptera	0	0	0	0	0	0	0	0	0	0
Neuroptera	0	0	0	0	0	0	0.4	0	0	0
Odonata	0	0	0	0	0	4.3	0	0	0	2.857
Opiliones	0	0.3	0	0	0	0	0	0	0	0
Orthoptera	0	1.1	0	1.6	1.3	22.6	0.4	4.6	0.5	23.1
Plecoptera	0	0	0	0	0	0	0	0	0	0
Pseudoscorpiones	0	0	0	0	0	0	0	0	0	0
Psocoptera	0	0	0	0	0	0	0	0	0	0
Solifugae	0	0	0	0	0	0	0	0	0	0
Thysanoptera	5.0	0	4.2	0	0	0	204.2	0.2	0.5	0
Trichoptera	0.4	0	0	0	0	0	0	0	0	0
Unknown	2.5	0	0	0	0	0	0	0	0	0